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SPACE

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MANNED MISSION HIGHLIGHTS

PHOTO OF INTERIOR OF 'SOYUZ T' CABIN

Frankfurt am Main SOLDAT UND TECHNIK in German No 8, Aug 81 p 453

[Article: "The New Soviet Soyuz T Spaceship: A Capsule for Three Astronauts"]

[Text] On 16 December 1979, the Soviet Union launched for the first time a Soyuz spaceship that can hold three astronauts. The third-generation space ferry, designated the Soyuz T-1 (Troika), was launched unmanned and docked three days later with the Salyut-6 space station (in orbit since September 1977). After 101 days, the Soyuz T-1 was separated again and returned to earth.

On 5 June 1980, two Soviet astronauts, Yuriy Malyshev and Vladimir Aksenov, were launched into space in the Soyuz T-2 spaceship for a test flight. They docked with the Salyut-6 for three days and conducted scientific experiments there together with the basic crew of Soyuz-36.

On 27 November 1980, three experienced Soviet astronauts, the commander Lieutenant Colonel Leonid Kizim, the flight engineer Dr. Oleg Makarov and the research engineer Dr. Gennadiy Strekalov, were launched into space in the Soyuz T-3 spaceship. They subjected the spaceship to extensive tests and docked for 12 days with the Salyut-6 space station, that has been in space since September 1977, to check on its further functional capability. Externally, there is hardly any difference between the new T series spaceships and the traditional Soyuz space ferries. Their length is 7.6 m, diameter is 3 m and launch weight is 6.5 t. Compared to the previous Soyuz ships, the Soyuz T has a new computer to control the entire autonomous flight, monitor the flight systems and transmit data to earth. Seating is arranged so that the commander is in the center with the flight engineer to his left and the research engineer to his right. Since the third man is not needed for spaceship control, this seat can be filled by a scientist, physician or maintenance specialist. Also new on the Soyuz T is the modern propulsion and control system. The old Soyuz ships had individual engines and independent support systems with different fuels. Now the main rocket engine and the vernier engines are supplied centrally from one device. Finally, the rescue system mounted on the nose of the spacecraft to be launched has also been improved. If malfunctions occur during the launch and initial flight phase, the rescue system switches off the main rocket engine of the launch vehicle, separates the spacecraft from it, ignites the rescue rocket engine and controls the emergency landing.

At present, the Soviet Union is using the Soyuz T along with the traditional Soyuz spacecraft. It is expected, however, that in the near future only the Soyuz T spacecraft will be launched into space from the Soviet space center at Baykonur.

A view of the interior of the new Soyuz T capsule, here the T-2, shows the use of digital instruments and computers. In our picture in the foreground is Lieutenant Colonel Malyshev and behind him the astronaut Aksenov. "A" points to the computer CRT display and "B" to the global flight path position indicator. Analog sequence control devices were installed in the earlier Soyuz capsules at "C." The number of indicator panels at "D" has been tripled. The periscope eyepiece for determining the location of the capsule in space can be seen at "E."

8545
CSO: 1851/1

PRESS CONFERENCE ON ACCOMPLISHMENTS OF 'SALYUT-6' MANNED MISSIONS

Moscow IZVESTIYA in Russian 14 Jul 81 p 2

[Article: "Looking to Orbits of the Future"]

[Text] Unprecedented in length, the flight of the Soviet scientific orbital station "Salyut-6," already in its fourth year of operation, has become a glorious page in the history of cosmonautics. The achievement does not rely only in the great reliability and longevity of the on-board systems and equipment assemblies of this space laboratory--which in itself is an outstanding accomplishment of Soviet designers and scientists. The program of research completed by "Salyut-6" is noteworthy by virtue of its scope and its purposeful striving to reach solutions for fundamental problems of science as well as today's practical requirements on earth.

The press conference conducted in Moscow on 13 July for Soviet and foreign journalists was held for the purpose of discussing the basic achievements of five long-term expeditions on board the space complex "Salyut-6" - "Soyuz."

Presiding over the press conference was Yu. N. Chernyakov, press manager of the USSR Ministry of Foreign Affairs. He turned the podium over to A. P. Aleksandrov, academician and President of the USSR Academy of Sciences.

The president appraised the "Salyut"-"Soyuz" complex as a scientific orbital laboratory on board which a tremendous volume of research was conducted related to the study of near-earth space and astrophysical objects, as well as technological experiments and observations of the earth from space. Along with the instrumentation with which "Salyut-6" was equipped prior to its launch, new equipment for conducting on-board research appeared over its three years in operation, delivered by cargo transport space ships.

The academician took particular note of the great information-yielding capacity presented by the method of photographing the earth's surface from orbit. From the space station it takes only 10 minutes to put a million square kilometers of territory on film. Methods of aerial photography, for example, would require several years to do the same thing. A very important facet of studying the earth was work involving the exposure of large-scale geological formations, in particular geological fissures which usually coincide with deposits of mineral resources. Those who study the science of materials received quite a bit of information as well--data from experiments in crystallization and fusion of substances conducted in space under specific conditions of extraterrestrial environment. This is invaluable scientific material.

A. P. Aleksandrov also made a high appraisal of the international portion of the "Salyut"-"Soyuz" program in which cosmonauts from the fraternal nations participated. In conclusion he stated that studies conducted on board "Salyut-6" are an outstanding achievement of Soviet science and technology, and a major step along the path towards building a permanently-functioning orbital complex using interchangeable crews.

A. S. Yeliseyev, doctor of technical sciences, USSR pilot and cosmonaut, then took the floor.

He stated that work on near-earth orbital stations comprises the basis of the Soviet space program. As long ago as 1969, at a meeting in the Kremlin of the "Soyuz-6," "Soyuz-7" and "Soyuz-8" crews, Comrade Leonid Il'ich Brezhnev stated that Soviet science views orbital stations with interchangeable crews as man's major highway into space... Major scientific laboratories will appear for conducting research in space technology and biology, medicine and geophysics, astronomy and astrophysics.

Soviet scientists and builders of space technology view this as the most efficient path towards accomplishing many scientific and economic tasks. More than 1600 experiments in various areas of research were conducted during the flight of the "Salyut-6" station. A record was established for continuity of operation of the station in the manned mode. The greatest duration of continuous space flight for a single crew was 185 days.

The space complex "Salyut-6" - "Soyuz" - "Progress" is a new-generation orbital system. It contains within itself all the basic elements necessary for the existence of the future permanently-functioning space laboratories with interchangeable crews and replaceable scientific equipment. Manned transport space ships are used to deliver crews to the station and return them to earth. The use of two types of ships was envisaged in the flight program--"Soyuz" and "Soyuz T." The "Soyuz T" ship underwent flight testing and simultaneously provided supplies for operation of the complex. The flight testing has now been completed, and the ship is about to replace the "Soyuz" craft, which has already served 14 years. An important role in operational effectiveness of the complex has been played by the "Progress" cargo ships.

The academician R. Z. Sagdeyev, director of the Institute for Space Research of the USSR Academy of Sciences, discussed some very important scientific data received during the flight of "Salyut-6." He described experiments devoted to astronomy, geophysics, geology, the natural sciences, the science of materials, and other spheres of knowledge. Space technology experiments occupied an important position in the scientific program, the scientist stated. Their basic aim was to bring to light the peculiarities of certain processes under conditions of micro-gravitation, to find homogeneous semiconductor, optical, and other types of materials and to ascertain their future use in serving the needs of electronics, laser technology and infrared illumination instrumentation, among other aims.

Initial results of the research have yielded the promise of a new scientific direction. In developing the research program for the "Salyut-6" station related to the national economy, requirements of several hundred organizations of 22 of the countries ministries and departments were taken into account.

Addressing the international portion of the program completed by the cosmonauts, R. Z. Sagdeyev emphasized the continuity of the research. Each international expedition added its own instruments and equipment to the scientific apparatus already on board the station. This enabled the scope of the research conducted to expand significantly.

The flights of Soviet and international crews have become a shining example of the achievements of Soviet cosmonautics as well as of the scientific and technological cooperation of the socialist countries. Without a doubt, results of the research completed comprise an important contribution to world science.

In his address, the academician O. G. Gazenko stated that the tremendous work accomplished on the orbital complex "Salyut-6" - "Soyuz" has enabled us to accumulate valuable experience in the area of medical support for man's long periods in space. For almost two years--676 days--the orbital complex functioned in the manned mode of operation, over twice the duration of all previous manned flights of Soviet spacecraft and stations. Twenty-seven cosmonauts--six of whom went up twice--worked on board the station and accomplished a broad program of scientific and technical research and experimentation. Seven cosmonauts spent over 100 days in space--V. Kovalenok and L. Popov over half a year, and V. Ryumin almost an entire year.

O. G. Gazenko stressed that an analysis of research results is enabling us to optimistically assess prospects for increasing the duration of future space expeditions, to make a more accurate determination of basic aims for medical research as applied to future space flights.

Especially worthy of note, the scientist stated in conclusion, are the flights with international crews and the participation of representatives of countries of the socialist community in the "Intercosmos" program. Using equipment developed by specialists of the fraternal countries, a number of medical and biological research projects and experiments were carried out. Much of the instrumentation delivered to the space station was used not only during the flights with international crews, but for operations of the basic expeditions as well.

A discourse on those aspects specific to selection and training of the crews, and maintaining space flights at a modern stage in the conquest of near-earth space was presented to the journalists by Maj Gen Avn A. A. Leonov, Deputy Director of the Cosmonaut Training Center imeni Yu. A. Gagarin, pilot and cosmonaut of the USSR. He noted specifically that, in organizing the long-term expeditions for the "Salyut-6" station, we encountered for the first time the problem of forming our crews immediately prior to the flight. This happened, for example, when a leg injury suffered by V. Lebedev forced us to replace him with V. Ryumin. Here a decisive role was played by the experience of those cosmonauts who had already been in orbit on board the station and were taking a short break--this is a significant feature of our multi-expedition program. Also important is the fact that, for the first time, we had the opportunity to send cosmonauts to the space station who had already worked on board.

With regard to training the representatives of the other socialist countries, their preparation was accomplished in less than the usual time. In spite of the intensified pace, however, the crews successfully handled all phases of flight preparation

and, exhibiting courage and professionalism, they dealt with the tasks they were assigned in a praiseworthy manner. Discussing the success of the long-term expeditions, A. Leonov noted that a highly positive role in psychological support for the crews was played by television transmissions to the station--this is the first time such transmissions were made possible--and the setting up of a postal service between the cosmonauts and their families.

Scientists, specialists and cosmonauts then answered the journalists' questions.

9768
CSO: 1866/145

HOLOGRAM EXPERIMENTS IN SPACE

Leningrad LENINGRADSKAYA PRAVDA in Russian 19 Jul 81 p 2

[Article by Yu. Koptev, scientific reviewer for LENINGRADSKAYA PRAVDA]

[Text] I happened to visit an international holographic exhibit one day. Numerous countries offered displays. A crystal apple hanging motionless in the air looked lovely. Holographic portraits with frozen smiles created a strange impression. But what was really striking was this bas-relief of a lion's head. It was impossible to tell that it was simply a holographic apparition.

A hologram looks like an ordinary photographic plate with odd black and white divisions. But when it's illuminated a certain way an image shows up. The holographic picture has many advantages over a photograph. It is more informative; it yields a three-dimensional, spatial image of an object, and an image can be reproduced even from a small part of the hologram. The larger that part is, of course, the better will be the quality of the image.

The hologram has one more very substantial advantage. One can work with it as with a conventional item--measure its transmittance, reflecting power and so on. For example, it's possible to film things that are hard to get to and processes which take place under inaccessible conditions, and then study them in the laboratory with the traditional instruments and equipment. These properties of holography are already in use for scientific purposes at many of the world's research centers, including the Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences, in the laboratory of optoelectronics and holography.

A Communications Facility

Work on holography started at the Physicotechnical Institute 15 years ago under the initiative of Academician B. P. Konstantinov. The possibility of holographic television systems was here demonstrated and special devices for a holographic memory were developed. The Leningrad physicists were long ago interested in the problem of long-distance transmission of holograms via conventional means, television in particular. S. B. Gurevich, G. A. Gavrilov, D. F. Chernykh, V. B. Konstantinov and some others at the laboratory comprised the group of scientists who first set up this experiment. For the first time, a three-dimensional image was transmitted over channels of communication which had heretofore carried only plane

images. For instance, a hologram traveled to Moscow and back via facsimile channels. Cuban specialists R. Buergo and R. Oms soon got in on this work too, and as a result of the joint effort a hologram was transmitted all the way from Havana to our country via a Soviet communications satellite.

It should be noted that these experiments not only showed that the long-distance transmission of holographic information was entirely possible, but also enabled finding methods for operational checking and correction of the information.

Not long ago, during a Soviet-Mongolian flight under the "Intercosmos" program, astronauts V. A. Dzhanibekov and Zh. Gurragcha continued the Soviet-Cuban experiment on a fundamentally different level--with a space version. They transmitted a test hologram over a television channel from orbit to the screens of the Flight Control Center monitors on the ground. Holograms were also sent to the spacecraft where the astronauts photographed them from the screen of the video equipment and later delivered them to earth.

This experiment demonstrated that holography can be used successfully for exchange of information with space.

Experiment in Orbit

A new field of science--space materials technology--is presently being established. More than one experiment has been carried out to obtain this or that material while in orbit. For example, scientists are interested in how substances behave during crystallization under conditions of weightlessness. On the ground, all solutions and melts mix because of two processes--diffusion and convection. Due to convection the warm particles of a substance, i.e., the light particles, move upward and the cold, heavy ones settle. When there is no gravity there is no convection. So how do materials behave under such conditions during melting, during crystallization?

The highly regarded "Splav" and "Kristall" furnaces, built by Soviet specialists, were installed aboard the "Salyut-6" orbital station. Thousand-degree heat prevails in these furnaces and it is no more possible to make their walls--ampules containing the substance undergoing study--transparent than it is possible to make the walls of a reactor transparent. There is no glass that can withstand such high temperatures. The scientists, well aware of the original state of the material and the end result of the experiment, were unable to tell anything about the phases in between. They could only surmise or calculate but were, alas, powerless when it came to observing them.

While work was going on at the Physicotechnical Institute, the Cuban specialists proposed an interesting experiment which was given the name "Holography". The idea was quite simple: Since one can not peek into the red hot reaction vessel, one has to study the processes with crystals that grow and dissolve at ordinary tempertures. Such processes can be run in reaction vessels with ordinary glass walls, through which everything can not only be easily seen but photographed as well. It was suggested that sodium chloride be used for the astronauts to watch dissolve. In order to obtain as much information as possible it was decided to do the

photography with laser beams, i.e., to produce holograms of the process. Incidentally, an analogous experiment is planned for one of the future flights by American scientists, involving not dissolving but growing a salt crystal.

It is to be noted that the holographic equipment used on the ground is very fickle and cumbersome. It sometimes weighs several tons. Not only is the equipment itself heavy, but also the massive plate, which rests on the foundation or on special shock absorbers intended to eliminate vibrations during photography. Nevertheless, if a streetcar rumbles by or a heavily loaded truck speeds past the hologram is not obtained. For space, however, it was necessary to develop a light and compact version of the holographic apparatus not affected by vibrations--not one of your easy assignments. Considerable work and inventiveness were required of the scientists in order to come up with a mini-holograph weighing about as much as a hand-held movie camera. (We note that the American apparatus will be about 50 times greater in both weight and bulk.)

In order to avoid the effect of vibration, the apparatus was put together on a special frame which tightly connected all of its elements. The viability of the design is confirmed by the fact that it was tested on a fast passenger express. The car swayed and shook but nothing affected the quality of the holograms. Work on the development of the unique device was supervised by S. B. Gurevich, head of the laboratory. However, numerous difficulties would not likely have been overcome had it not been for the interesting ideas proposed and subsequently implemented by senior scientific associate V. B. Konstantinov. Then, too, there was the design talent of D. F. Chernykh, candidate of technical sciences, and the golden hands of mechanics V. M. Levushkin and D. A. Metelkin. S. A. Pisarevskaya, M. S. Cheberyak and others at the laboratory put a lot of effort and skill into the adjustment and testing of the apparatus. To finish up, all had to work evenings and on their days off; schedules were compressed and every hour made to count.

By the time of the Soviet-Cuban flight in September of last year the "Hologram-1" experiment, using the apparatus developed at the Physicotechnical Institute, was ready. It was to enable the scientists not only to see inside the reaction vessel, but also to observe the crystallization "kitchen" under laser beams. However, the international crew's work program was so filled up that there was no way to include this experiment in the research plan. It was turned over to the "Soyuz T-3" crew of L. Kizim, O. Makarov and G. Strekalov, who did indeed produce the holograms in space. The Mongolian astronaut subsequently continued the work. Such continuity is typical of the "Intercosmos" program where many experiments are repeated and amplified by successive crews.

So the pictures were received from space, the holograms were developed and the images reproduced. In the middle of the image is a square--the dissolved crystal. Around it are peculiar petals, the front of the salt solution which is mixing slowly in fresh water. This couldn't be seen were it not for the laser beams since both the water and the solution are transparent in ordinary light.

Meteorite Tracks

In conclusion, a few words about an interesting application of the holographic apparatus aboard the "Salyut-6".

How often we have read in fictional prose about the astronauts' encounter with the "wanderers of space"--meteorites. Unfortunately, such events occur not only on pages of books. There have been several cases when artificial satellites and automatic interplanetary stations have malfunctioned because of them.

An encounter with a large meteorite is a rarity. But small particles are encountered rather frequently, particularly in meteorite showers. An average of one or two micrometeorites hit the "Salyut" every orbit. They are small in size, but their high velocities make it impossible to avoid collision. It is necessary to reckon with this factor in the planning of space equipment. The "Salyuts", for example, are protected from meteorite particles by a special shield; but the portholes remain vulnerable and nearly all of them show evidence of such collisions.

The scientists' interest in these "marks" is understandable. But how do you study them when you can't get to them? Ordinary photographs won't do. The sun blinds the cameras and the pictures reveal nothing about the depth of the tracks or what they are like. A three-dimensional picture was needed. So the Physicotechnical Institute's apparatus (with minor modifications) was put to use. Astronauts V. Kovalenok and V. Savinykh took holographic pictures of one of the portholes in the course of their flight.

Usually, when a piece of space gear is developed it is checked out on the ground. But in this case everything was otherwise. The unique device developed by the Leningrad scientists got its "space visa" first. And now, say its developers, it can be used successfully for scientific and technical purposes on the ground.

5454
CSO: 1866/151

'SALYUT-6': COMMUNICATION AND TELEMETRY SYSTEMS

Moscow PRAVDA in Russian 29 Mar 81 p 6

/Article by B. Pokrovskiy, scientific staff member, command and telemetry complex: "A Conveyor With the Speed of Light"/

/Text/ The "Salyut-6" has been operating in orbit continuously for 3 and 1/2 years. The flight is unprecedented in its complexity, duration and the results that have been achieved. During this time the station has traveled about 850 million kilometers and circled our planet more than 20,000 times.

Along with Soviet cosmonauts, representatives of the fraternal socialistic countries have participated in the orbital working marathon that is the "Salyut-6." Right now a scheduled international expedition, consisting of V. Kovalenok, V. Savinykh, V. Dzhanibekov and Zh. Gurraghcaa, is working amicably on board this station. In all, 31 tamers of the Universe have visited the station in 3 years.

How do the cosmonauts live and work in orbit? How do they conduct experiments and research? Is everything really in order on board the station? The managing specialists, engineers, physicians and designers find out about all this by radio and television conversations with the crew members. The cosmonauts will bring much interesting scientific material, moving picture and photographic film and entries in on-board journals to Earth at the completion of their flight. Nevertheless, the scientists receive the greater part of their information from orbit over a constantly operating electronic conveyor. Flows of information broken up into an infinite set of radio signals pass along it at the speed of light.

Through ground stations belonging to the command and telemetry complex and expedition ships of the USSR Academy of Sciences, the conveyor connects the "Salyut-6" station to the Flight Control Center. When the repeater satellites are included in it, this conveyor reaches 80,000 kilometers in length. This extremely complex ground and space system also includes automated communication links, highly productive computers, facilities for connecting them and other equipment. They make it possible not only to transmit and process huge masses of information, but also to display the basic results, on a real time scale, on television screens, electronic indicator boards and illuminated maps at the Flight Control Center.

As far as its content is concerned, the information is categorized as orbital, telemetric, command and programming, and television and radio conversations with the cosmonauts. Orbital information can contain data on a single orbital parameter,

such as only range or radial velocity, or on several, such as range, radial velocity, two angles and two angular velocities.

The amount of orbital information increases noticeably during the performance of such critical stages in the flight of the station and the spacecraft meeting it as takeoff, maneuvering, orbital corrections, departure from the station into the descent trajectory, and landing. For instance, the number of measurements made (and this means information, also) during orbital correction and takeoff exceeds the figure for a "dynamically quiet" flight by factors of 5 and 10, respectively. And let us remember here that in 3 and 1/2 years, 17 transport and 12 cargo craft have docked with the station and dozens of orbital corrections have been made.

Orbital information is needed by the ballistics specialists in order to determine the actual orbit, compare it with the theoretical one, and predict the future path for spacecraft. It is needed so that the tracking stations can be told how to orient their ground antennas when satellites appear in the radio visibility zone on successive orbits, so that decisions about the need for an orbital correction can be made, and so that the docking conditions and landing site can be defined more precisely.

Instructions on turning the engines on or off on the orbital station or on "Soyuz" and "Progress" ships and about changing the operating mode of their on-board systems are transmitted to them by ground stations. They can be distorted because of interference. Therefore, a command that has arrived on board is not transmitted to the actuating mechanisms as soon as it is received, but with some delay. This is necessary so that the on-board transmitter can send to Earth an "acknowledgement" -- confirmation of the command's receipt and contents. Having confirmed its accuracy, the Flight Control Center sanctions the implementation of the command. This exchange involves a special and very important type of information: command and programming.

However, the electronic conveyor's basic load is telemetric information. Thousands of sensors at monitoring points in the orbital complex report on the state of affairs on board. Telemetric information can be divided into three approximately equal parts, according to content: the results of medical monitoring of the state of the cosmonauts' health and the functioning of the life support systems; scientific research and experiments; the state of the equipment and structures.

After processing, the telemetric information is used by physicians, specialists in the diagnostics of the on-board systems, spacecraft designers and scientists at institutes belonging to the USSR Academy of Sciences. Quantitatively, the amount of telemetric information exceeds that of orbital and command and programming information, taken together, by several orders of magnitude. Its total volume amounts to more than 100 million binary digits per communication sessions.

Is this a lot or not? Judge for yourself: a word for word transmission of the text of a single issue of a newspaper such as PRAVDA would require approximately 0.5-1 million (depending on the number of pages) binary digits. And over a period of a month, there are about 500 communication sessions with the "Salyut-6"-"Soyuz" complex. However, even this amount of information does not give the full picture of the load carried by the electronic conveyor. Actually, the ground and marine tracking stations work simultaneously with dozens of other spacecraft that are

actively functioning in orbit at this time. It is clear that such huge masses of information can be handled only with the help of the most modern mathematical methods and equipment.

However, not all of the data from this flow of information are needed constantly by the specialists. For example, air humidity, temperature and composition, the state of the cable network and the spacecraft and station structures, and many other "onboard" parameters do not change over a long period of time and remain stable, for all practical purposes. However, information about all of these factors is gathered regularly, since they must be monitored constantly. However, in order not to overwork the specialists and technicians needlessly, special "filters" have been designed that reject repeating information before it is sent out. As a result, only information of scientific and practical value arrives on Earth.

Achievements in electronics and cybernetics, information theory and mathematics, are offering us new possibilities for improving our integral information and computer systems. The time is coming when, as is now the case with electricity and communication systems, institutes, enterprises and organizations will be connected to the information-carrying ground and space systems. They will use information of the most diversified types, gathered in space, for scientific and practical purposes: monitoring the environment and the status of crops; controlling the movement of transport facilities and studying the natural resources of Earth. This is without even mentioning what has already come to pass to the benefit of our national economy: satellite communication, meteorology and navigation systems. In a word, the possibilities for using cosmonautics to further the people's interests are unlimited.

11746
CSO: 1866/113

UDC 681.142.019.3

CONSTRUCTING RELIABLE ESTIMATES OF ARTIFICIAL EARTH SATELLITE ORBIT PARAMETERS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81
(manuscript received 1 Oct 79) pp 19-25

PETROVSKIY, F. D., BEZRUCHENKO, T. I. and GOLOVANOVA, N. A.

[Abstract] The authors present a method for constructing reliable unidimensional estimates of the parameters of artificial Earth satellite orbits that is based on finding the maximum of a function, which method can be used with sufficient :uracy even when there are random errors in the measurements. They then extend it to the multidimensional case and reach the following conclusions: their method makes it possible to construct multidimensional estimates of orbital parameters even when gross measurements are used; when there are no gross measurements, this method produces results at a level of accuracy close to that achieved with the method of least squares. Its advantages over several other methods are that the estimate is only slightly dependent on prior knowledge of the probability of the appearance of gross measurements and that the estimate calculation algorithm is simple and easy to use. Figures 5; references 11: 9 Russian, 2 Western.
[87-11746]

UDC 551.521.8

DETECTING ELECTRON ACCELERATION PHENOMENON IN IONOSPHERE PLASMA AFFECTED BY EMISSIONS NEAR LOCAL PLASMA FREQUENCY FROM POWERFUL RADIO TRANSMITTER ON 'INTERCOSMOS-19' SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81
(manuscript received 21 Jul 80) pp 34-44

GAL'PERIN, Yu. I., SAGDEYEV, R. Z., SHUYSKAYA, F. K., LISAKOV, Yu. V., MIGULIN, V. V., KUSHNEREVSKIY, Yu. V., FLIGEL', M. D. and VASIL'YEV, G. V.

[Abstract] The "Intercosmos-19" satellite, launched 27 February 1979, carried a considerable amount of equipment for investigating the ionosphere, from the

results of which he authors present and discuss data obtained on characteristics of surges of superheated electrons appearing in the plasma around the satellite during pulse radiosounding of the atmosphere. The measurements were made by a soft electron spectrometer aboard the satellite. The authors describe the equipment, give the parameters of the data (surge duration, energy spectrum of the electrons, geophysical conditions), and compare the results with those of other experiments. Figures 5; references 22: 5 Russian, 17 Western.
[87-11746]

UDC 551.510.535.4

INVESTIGATION OF VARIATIONS IN N^+ AND O^+ ION CONCENTRATIONS, DYNAMICS OF IONOSPHERE AND ENERGETIC ELECTRON FLOWS IN OUTER IONOSPHERE FROM 'METEOR' SATELLITE: 3. HIGH-LATITUDE IONOSPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 20 Apr 79) pp 45-52

IVANOV, G. V., PERKOV, I. A., POGULYAYEVSKIY, L. I., ROMANOVSKIY, Yu. A., RYLOV, Yu. P. and YAICHNIKOV, A. P.

[Abstract] During a mass spectrometer experiment with a "Meteor" satellite in 1976, an attempt was made to conduct a detailed, integrated investigation of the relationships among ion distributions in the outer high-latitude ionosphere, energetic electron flows, and large-scale convective movements. The author discuss the spillage of geoeffective electrons and convection in the high-latitude ionosphere, features of the distribution of N^+ and O^+ ions in this zone under undisturbed conditions, and the effects of disturbances during magnetic storms. They conclude the following: in the unilluminated ionosphere, increased concentrations of N^+ and O^+ ions correlate spatially with the spillage zones of electrons with E 350 eV; during geomagnetic disturbances these concentrations increase greatly and this phenomenon and increased electron spillage extend into the middle latitude ionosphere. Figures 3; references 15: 6 Russian, 9 Western.
[87-11746]

UDC 581.521

RECURRENT INCREASES IN LOW-ENERGY PARTICLE INTENSITY, ACCORDING TO MEASUREMENTS MADE BY 'PROGNOZ-3' ARTIFICIAL EARTH SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 3 Dec 79) pp 53-65

ZEL'DOVICH, M. A. and LOGACHEV, Yu. I.

[Abstract] In increases in the intensity of protons with energy levels up to 20 MeV, recurrent increases with a period of 27 days play a significant part.

The authors present the results of an analysis of increases in the intensity of protons with E_p = 1-4.5 MeV and electrons with E_c = 40-500 keV that are not related to solar flares. The basic data were gathered by the "Prognoz-3" satellite from February 1973 to February 1974. As a result of their analysis and a comparison with the recurrent events registered by the "Pioneer-11," they reach the following conclusions: recurrent flows appear at a distance of 1 A.U. as frequently as they do at greater distances; the structure of the flow remains the same, regardless of the distance; the intensity of the events changes in various ways from 1 A.U. to greater distances; in Earth's orbit, recurrent flows are seen not only at the front of a high-speed flow, but also during a decline and at the minimum of the solar wind; in about half of the events seen, the anisotropy of the entire flow or part of it was greater than +20%; electrons are always present in recurrent flows at 1 A.U. Figures 8; references 18: 7 Russian, 11 Western.
[87-11746]

UDC 581.521

CAPTURE BOUNDARY OF ELECTRONS WITH E_e > 0.7 MeV DURING PERIOD OF PROTRACTED MAGNETIC DISTURBANCES IN AURORAL ZONE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 26 Oct 79) pp 66-70

GINZBURG, Ye. A. and MALYSHEV, A. B.

[Abstract] The authors present the results of observations of the behavior of flows of electrons with E_e > 0.7 MeV, at an altitude of about 900 km, near the high-latitude boundary of such flows on the night side of the magnetosphere during protracted magnetic disturbances in the auroral zone. The flows were measured in August and December 1975 by a "Meteor" satellite with an orbiting period of about 102 min. From their analysis of these observations, they conclude that there are periods when: in the auroral zone there are protracted (several hours) negative magnetic disturbances with intensities ranging from several hundred to 1,000 or more nanoteslas; D_{st}-variation on the order of about -20 to 30 γ is seen on the Earth's surface in the low latitudes; on the night side of the magnetosphere, the high-latitude boundary of flows of electrons with E_e > 0.7 MeV is registered at latitudes considerably lower than under calm conditions. They also state that there is now a possibility, in principle, of diagnosing the different stages of a substorm on the basis of the behavior of high-energy electrons at low altitudes on the night side of the magnetosphere. Figures 2; references 15: 8 Russian, 7 Western.
[87-11746]

UDC 581.521

STRUCTURE AND DYNAMICS OF AURORAL PROTONS AND ELECTRONS WITH ENERGIES OF TENS AND HUNDREDS OF KILOELECTRONVOLTS, ACCORDING TO MEASUREMENTS MADE BY 'COSMOS-900' ARTIFICIAL EARTH SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 10 Dec 79) pp 71-75

KOVTYUKH, A. S., PANASYUK, M. I., REYZMAN, S. Ya. and SOSNOVETS, E. N.

[Abstract] Differential spectrometers with semiconducting detectors, installed in the "Cosmos-900" satellite, were used to gather data on protons with energy levels of 50-506 keV and electrons with energy levels of 50-210 keV in the auroral zone during a magnetic storm that began on 11 Dec 77. The authors analyze the data gathered during 35 passes of the satellite, then present and discuss the conclusions they reached about the structure and dynamics of these particles. Figures 3; references 7: 3 Russian, 4 Western.
[87-11746]

UDC 581.521

ANISOTROPY OF FLOWS OF ELECTRONS AND ALPHA-PARTICLES WITH ENERGY LEVELS GREATER THAN 4 MeV IN RADIATION BELTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 10 Dec 79) pp 76-81

PANASYUK, M. I. and VLASOVA, N. A.

[Abstract] The "Molniya-2" artificial Earth satellite was used to gather data on protons and alpha-particles on 25 October 1975. In the authors' discussion of the results, they state that the following facts have now had reliable experimental confirmation: the greater anisotropy of alpha-particle flows in comparison with flows of electrons with about the same energy level leads to a reduction in the N_a/N_p ratio as there is an increase in the geomagnetic latitude when L is constant; at energy levels of several megaelectronvolts, alpha-particle flows are dominant inside the radiation belts. There also appears to be a relationship between the pitch-angle distribution and the L-shell, while the N_a/N_p ratio, normalized for the energy interval 4-10 MeV and reduced to the geomagnetic equator, is greater than unity at $L \geqslant 2.6$. Figures 4; references 12: 3 Russian, 9 Western.
[87-11746]

UDC 531.36

MOTION OF SATELLITE RELATIVE TO CENTER OF MASS IN ELLIPTICAL LIMITED THREE-BODY PROBLEM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 29 May 80) pp 178-190

MARKEYEV, A. P. and KRASIL'NIKOV, P. S.

[Abstract] Equations are written and solved for the rotational motions of a satellite in a three-body formulation with the following assumptions: 1. The satellite is a solid of infinitely small mass, subject to the gravitation of two spherical bodies; 2. In a baricentric system of coordinates, its center of mass moves in some arbitrary conditionally periodic orbit; 3. Its ellipsoid of inertia is close to a sphere; 4. Classical perturbation theory is applicable. The unperturbed motion takes the form of uniform rotation about a reciprocating vector of constant absolute value for the kinetic moment of the satellite. The nonresonant rotations of the satellite are analyzed; for such orbits of the center of mass, the evolutional equations for the rotational motions allow for complete separation of the variables. The rotation is composed of Euler-Poinsot motions about the kinetic moment vector and motions of the vector itself. A qualitative study of the motions of the latter is carried out with the additional limitation that there are no orbital motion resonances. The kinetic moment vector executes precessional motions when the finite bodies describe circles around the common center of mass. The regular precession is also preserved in the slightly elliptical three-body problem if the satellite's center of mass does not leave the plane of rotation of the bodies of finite mass during its motion. For spatial orbits, the precession of the kinetic moment axis splits into librational motions in the vicinity of some of its positions relative to equilibrium and rotational motion. The influence of the type or orbit on the rate of travel of the kinetic moment vector along its trajectories relative to the satellite and on the motion of the vector itself in space is also analyzed. This is illustrated with the relative motions of a satellite in spatial conditionally periodic orbits close to the collinear L_2 libration point in a circular three-body problem. The purely theoretical treatment adduces neither numerical examples nor experimental data. Figures 3; references 33: 24 Russian, 9 Western.
[121-8225]

UDC 629.7

LIBRATION POINTS IN PROBLEM OF GRAVITATING ELLIPSOID WITH THREE AXES; STABILITY REGION GEOMETRY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 20 May 80) pp 200-209

KOSENKO, I. I.

[Abstract] Libration points are present on the extension of the major semi-axis of the equatorial cross-section through a uniformly rotating gravitating ellipsoid

which is assumed to be asymmetrical and homogeneous in the general case. The parameters chosen for the mechanical interpretation of libration point stability and the geometry of the stability range are the square of the length of that equatorial section semi-axis of the ellipsoid, on the extension of which the libration point falls; the square of the length of the semi-axis perpendicular to it in the plane of the equator; and a parameter which characterizes the distance of the libration point from the ellipsoid surface. The detailed mathematical derivations are predicated on the definition of an infinite manifold in Euclidean space which is used as the parameter space for the system of equations defining libration region stability. It is found that for such a gravitating rotating object with a homogeneous mass distribution, the libration point will be stable in a first approximation if the first of the chosen parameters above is less than the second, i.e., the square of the length of the semi-axis perpendicular to it in the plane of the equator; this is the case if the planet is either close to the shape of a sphere for any distance of the libration point from its surface, or for an ellipsoid of arbitrary shape having a sufficiently remote relative equilibrium point. The relevant theorems and lemmas are stated and proved. Figures 5; references 2 (Russian).
[121-8225]

UDC 531.38

INFLUENCE OF ALTITUDE CHANGE OF HOMOGENEOUS ATMOSPHERE ON MOTION OF AN ARTIFICIAL SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 25 Jan 80) pp 210-220

NOSKOV, B. N.

[Abstract] A power series derived by A. M. Fominov for the density of a spherically symmetrical atmosphere as a function of altitude is used as the basis for the analytical description of perturbations in an Euler orbit. Differential equations are written and solved to find the secular and long period perturbations in such satellite orbits which are due to variations in the altitude scale. The detailed mathematical analysis results in lengthy but explicit expressions suitable for practical calculations in cases where all values of the orbital element, e, (the analog of Keplerian orbit eccentricity) are less than unity. No sample calculations or experimental checks are noted. References 15: 13 Russian; 2 Western.
[121-8225]

UDC 551.521.8

PULSATIONS OF QUASI-CAPTURED ELECTRONS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 11 Jul 79) pp 232-238

KUZNETSOV, S. N., LOPATINA, G. B. and STOLPOVSKIY, V. G.

[Abstract] Electron fluxes with an energy of more than 1.4 MeV were registered by a global detector in the Cosmos-721 satellite from 26 Mar to 5 Apr 1975 (flight altitude about 220 km, inclination about 81°). About 180 such pulsations were observed in 78 revolutions of the satellite, where the number of pulsation periods varied from 1 to 11. The telemetry interrogation frequency of once every 10 sec allowed for the study of pulsations only with a period of greater than 20 sec. The maximum average probability of observing pulsations in the day and night hemispheres of the earth (6-18 and 18-06 hr MLT) falls in a range of 66 to 68° of latitude, while the majority of pulsations are observed in a range of 56 to 72°. The distribution of the pulsations with respect to periods and amplitudes is found to be a clear function of the geomagnetic longitude. Longitude ranges of 210 to 50° and 50 to 210° were ascertained. The difference between the periods and amplitudes in these ranges is related to the different physical conditions in the particle recording region. A comparison of electron intensities at energies greater than 30 and greater than 300 KeV from Cosmos-484 data indicates the different nature of the pulsations of these fluxes. The energies of particles which could cause bounce-drift resonance are estimated: electron intensity pulsations for energies greater than 30, 300 and 1,400 KeV do not indicate the presence of the requisite particles in the earth's radiation belts, with the exception of protons at energies of 100 KeV or less. It is possible that the period of the observed pulsations is related to the resonance properties of the magnetosphere, while the electron precipitation pulsations are possibly linked to the modulation of energetic particle fluxes by geomagnetic pulsations. Figures 6; references 11: 7 Russian, 4 Western. [121-8225]

UDC 551.510.535.4

SATELLITE POTENTIAL AND EFFICIENCY OF ION COLLECTION BY MASS SPECTROMETER ANALYZERS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 23 Apr 79) pp 239-243

YAICHNIKOV, A. P.

[Abstract] The difficulty in the interpretation of mass spectrometry data is due to the lack of constant and precise monitoring of satellite potential;

the influence of this potential on ion collection effectiveness is due to two major factors: 1. The change in the incident flux at the input aperture in the double layer at the surface of the satellite; 2. The change in the ion optical characteristics of the analyzer for ions accelerated in the double layer. This paper theoretically analyzes ion collection efficiency as affected by the second factor, adducing analytical expressions for the distribution of the ion flux with respect to the angle of attack and the aperture function of the spectrometer. Calculations are then made with the following assumptions: the ion temperature is 2,000°K, the satellite velocity is 10 km/sec, the ratio of the collector diameter to the analyzer length is 0.147 and the attack angle is 0°. The efficiency of ion collection is plotted in relative units as a function of the ratio of ion velocities outside and inside a MKh-6405 mass spectrometer for H^+, O^+, and He^+ ions in the case of "Elektron" series satellites. The O^+ ion current is also plotted as a function of the attack angle of the A1 analyzer of the MKh-6407 spectrometer at satellite potentials of 0, -0.5 and -4 volts. The impact of negative satellite potential on collection efficiency is manifest in a change in the ion-optical parameters of the analyzer; the negative potential leads to discrimination with respect to ion masses, where the efficiency is less for light ions than for heavy ones; and mass discrimination is minimal at a zero attack angle and increases with an increase in the angle. Figures 2; references 9: 7 Russian, 2 Western.
[121-8225]

UDC 621.384.523.72

PHOTOGRAPHIC STUDIES OF EMISSION LAYERS OF EARTH'S ATMOSPHERE DURING MANNED 'SALYUT-6' SPACE STATION MISSION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 15 Feb 80) pp 244-248

GRECHKO, G. M., ROMANENKO, Yu. V., SAVCHENKO, S. A. and SIMAKOV, S. V.

[Abstract] A brightness amplifier was used for the first time to photograph the emission layers of the atmosphere by G. M. Grechko and Yu. V. Romanenko from the Salyut-6 on 15 Mar 78 in the region of the geomagnetic equator. Images were obatined in 14 frames through a device with a brightness gain of 2,000; this made it possible to get good quality exposures at 1/15 to 1/60th second. The photometric measurements of the negatives were made with an IFO-451 microphotometer. Graphs are plotted for the distortion, nonuniformity in the exposure density of the negative when photographing uniform background, the characteristic curve of the film as well as comparative curves for the distribution of the emission layer brightness as a function of the angle in space (from -1.5 to 8°). The maximum brightness was: for the first emission layer, 4.8—$6.2 \cdot 10^{-3}$ cd/m^2; and for the second layer 1.2—$1.6 \cdot 10^{-3}$ cd/m^2. These figures are in good agreement with earlier literature. Figures 4; references 3 (Russian).
[121-8225]

UDC 629.197

VARIANT OF METHOD OF USING EARTH FOR SELENOGRAPHIC REFERENCING OF LUNAR PICTURES TAKEN FROM SPACE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 15 Apr 80) pp 300-304

SHEVCHENKO, M. Yu.

[Abstract] Equations are written and the solutions given which permit the selenographic referencing of lunar photographs taken from space which include the earth based only on the information contained in the photograph itself. There is no need for reference points on the lunar surface or trajectory data. The proposed technique also includes a correction for the distortion of the height of the center of the earth's disc above the lunar horizon due to parallax. The procedure was used to determine the coordinates of 18 selected craters in two space photographs with the image of the earth above the lunar horizon, taken from the "Zond-8" on 23 Oct 70. The precision of the technique was then determined by comparison with known coordinates from Soviet catalogs. The errors characterized not only the precision of the method itself, but also the relative errors in the catalogs. The experimental check was made only to test the procedure and a more careful accounting for the various errors (deformation of the photographs, objective distortion, etc.) will increase the accuracy. Based on a listing of coordinates in the region of the Eastern Mare on the back side of the moon, the systematic and random latitude errors were -1.7 and ±8.7' respectively, and the corresponding longitude errors were -6.1 and ±18.9' respectively. The systematic and random errors in latitude according to another catalog were +9.1' and ±20.5' respectively while the corresponding figures for the longitude systematic and random errors were -15.5' and ±22.0'. The method eliminates the problem related to the general rotation and deformation of the coordinates which occurs through the reduction of the accuracy of selenodesic grids of boundary regions when transferring the coordinates from the visible side of the moon to the back. Figures 3; references 9 (Russian).
[121-8225]

UDC 523.745

ARTIFICIAL LUMINESCENCE OF IONOSPHERE OUTSIDE REGION OF DIRECT INTERACTION OF ELECTRON BEAM WITH AMBIENT MEDIUM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 22 Jan 80) pp 306-309

ADEYSHVILI, T. G. and MANAGADZE, G. G.

[Abstract] In the "Stereotop" experiment a pulsed electron beam was fired into the ionosphere from an MR-12 rocket. The period between pulses was 6 seconds with a pulse train width of about 0.6 sec; in this quasi-pulsed mode, the angular

divergence of the beam was no more than about 7° while the energy and electron current in each pulse was 3 to 5 KeV and 0.2 A. The rocket carried a modulation photometer, a mass spectrometer, a potential sensor, electric field sensors and a magnetometer; it was launched from the region of Volgograd on 1 Dec 78. The configuration of the instrumentation on board the rocket is shown and its operation during the flight is discussed. The luminescence relaxation time for the green line of atomic oxygen (after beam injection was terminated) varies with altitude and falls off from 0.5 sec to 0.2 sec in a range of 140 to 95 km. Various ionospheric perturbation mechanisms are analyzed and the lower bound of the characteristic size of the perturbed region is estimated: approximately 230 m, depending on altitude, and at 130 km, it was about 260 m. At altitudes of 100 to 130 km, the size of the perturbed region is governed by the recharging of accelerated ions at neutral components of the ionosphere, which is the dominant process; it can be anticipated that at altitudes of 140 km and up the characteristic size of the region will match the Larmor radius of the accelerated ions. Figures 2; references 11: 6 Russian, 5 Western.
[121-8225]

UDC 581.521

RECORDING OF RELATIVISTIC PARTICLES BY 'COSMOS-900' SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 21 Jan 80) pp 310-312

GORCHAKOV, Ye. V., IOZENAS, V. A., TERNOVSKAYA, M. V., AFANAS'YEV, V. G. and AFANAS'YEV, K. G.

[Abstract] Since previous measurements of excess radiation close to the earth beneath the radiation belts and in the upper layers of the atmosphere with Cerenkov detectors did not fully resolve the question of why the radiation intensity was low (about 10^{-2} particles/cm^2·sec·sr), a new Cerenkov detector was installed in the "Cosmos-900", launched on 30 Mar 1977. The new instrument had a geometric factor 20 times greater than the earlier ones and functioned reliably until 11 Oct 1979. The radiator in the detector was a plexiglass sphere 30 cm in diameter coated with white flat paint on the outside. Cerenkov radiation was registered by an FEU-49 photomultiplier, where the instrument had 20 eight-place binary telemetry channels, capable of detecting charged particles and differentiating particles with atomic numbers of Z equal to or greater than 1, 2, 3, 4, 5, 6. A block diagram of the device is drawn and the probability of registering particles with various Z and energies in the various channels are plotted as a function of E in MeV/nucl. The count rate registered at the equator by the first channel (E_p more than 500 and E_e more than 10 MeV) in the "Cosmos-900" was about 200 pulses/sec and the corresponding figure from the "Cosmos-137" was about 10 pulses/sec; the agreement is good, allowing for the factor of 20 increase in the geometric factor. The statistical precision when gathering data for 20 seconds at high latitudes is about 0.5% for the first channel. Figures 2; references 5 (Russian).
[121-8225]

UDC 581.521

MEASUREMENT OF ALBEDO GAMMA QUANTA FLUXES WITH ENERGIES OF 30 TO 400 MeV IN NEAR SPACE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 24 Sep 80) pp 312-314

GAL'PER, A. M., GRACHEV, V. M., DMITRENKO, V. V., KIRILLOV-UGRYUMOV, V. G., LYAKHOV, V. A., RYUMIN, V. V., ULIN, S. Ye. and SHVETS, N. I.

[Abstract] A gamma background experiment was performed in 1979 on board the Salyut-6—Soyuz—Progress orbital station, one of the tasks of which was to measure the albedo gamma quanta fluxes at energies of 30 to 400 MeV. The "Yelena-F" small gamma telescope was employed and is briefly described in this paper. The gas-filled Cerenkov counter incorporated in the instrument had a relativistic threshold factor of about 11; the angular aperture of the instrument was about 12° and lead filters were used to segregate the two energy bands: 30 to 410 MeV and 50 to 420 MeV. The albedo gamma quanta intensity is plotted as a function of the threshold geomagnetic cutoff rigidity R; the secondary electron flux at energies of 45 to 520 MeV is also plotted as a function of R. In a hardness range of 15 to 17.5 GV, the gamma quanta rate for energies of 30 to 410 MeV was 39 ± 23 $(m^2 \cdot sec \cdot sr)^{-1}$ at the equator and in a range of 3 to 5 GV, it was 232 ± 42 $(m^2 \cdot sec \cdot sr)^{-1}$. For albedo gamma quanta in a range of 3 to 17.5 GV, the differential energy spectrum index, alpha, was measured at 1.6 ± 0.5. The data confirm the observations published in earlier Soviet and Western literature for individual regions of the earth. Figures 3; references 6: 2 Russian, 4 Western.
[121-8225]

UDC 535.568

ACTIVE EXPERIMENTS IN SPACE USING END-FACE PLASMA ACCELERATOR

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 21 Jan 80) pp 314-316

POROTNIKOV, A. A., OSTRETSOV, I. N., BALEBANOV, V. M., MANAGADZE, G. G., BRUKHTIY, V. I., GLOTOVA, N. N. and LYAKHOV, S. B.

[Abstract] A geophysical research rocket was launched to altitudes of 100-400 km in December 1978 at night from the "Volgograd" point in middle latitudes during a low level of geomagnetic disturbance. An on-board cesium continuous plasma accelerator with a power consumption of about 4 KW and an effective current of about 450 A, a working material consumption of 0.3 $g \cdot sec^{-1}$, an ion output velocity of about 1 $km \cdot sec^{-1}$ and a jet aperture angle of about 60° was used to generate a

plasma. The electron fluxes in the ionosphere were measured with a modified "Vol't" instrument with two miniature SI-19BG geiger counters having a detector geometry factor of 0.3 $cm^2 \cdot sr$ for a viewing angle of each counter of about 70°. The positioning of the "Vol't" instrument and the plasma accelerator on the rocket is sketched and the count rate is plotted graphically as a function of the flight time. The count intensity with the plasma accelerator off varied from $7 \cdot 10^{-2}$ to $2.2 \cdot 10^{-1}$ sec^{-1}, reaching a maximum in the vicinity of the apogee. With the accelerator on, there was a considerable increase in the detector count rate, which reached about 9 sec^{-1} and remained constant while the accelerator operated. No clear decision can be made between two possible explanations for this: that the increase in electron flux is responsible or whether it is due to the acceleration of ionospheric electrons with the development of plasma instabilities occurring during injection. Figures 2; references 9: 6 Russian, 3 Western.
[121-8225]

UDC 621.386.82

HIGHLY SENSITIVE DOSIMETER FOR SPACE RADIATION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81
(manuscript received 6 Aug 79) pp 316-319

MARKELOV, V. V. and RED'KO, V. I.

[Abstract] Radiation status monitoring in space requires dosimeters with a high dose sensitivity and low dose power sensitivity threshold. Existing dosimeters are deficient on both counts and provide information averaged over a large time interval and do not have the requisite space-time resolution of the dosage field. A design is described for a device which employs a silicon diffusion-drift detector with a sensitive region 0.8 mm thick and an area of 1 cm^2. The quantization level during dosage measurement is $1 \cdot 10^{-8}$ J/kg. The dose sensitivity is variable and the dosimeter can operate in a dose power range of from $2 \cdot 10^{-7}$ to 0.2 J/kg·hr. The overall measurement error does not exceed 15%. The design is described in detail and its operation is illustrated with the results of dosimetric measurements made during one of the orbits on 9 Oct 77 of the "Intercosmos-17" passing over the region of the South Atlantic Anomaly. The dose power and dose per particle during the revolution are plotted graphically as a function of time, clearly revealing the South Polar cap, the outer radiation belt, the inner belt, the North Polar cap and the equatorial region. Figures 2; references 6 (Russian).
[121-8225]

UDC 550.388.2

QUASISTATIONARY ELECTRICAL FIELDS AND SPILLING PARTICLES IN IONOSPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 20, No 6, Nov-Dec 80 (manuscript received 8 May 80) pp 1058-1066

GRIGORYAN, O. R., KUZNETSOV, S. N. and KLIMOV, S. I., Institute of Nuclear Physics, Moscow State University

[Abstract] In contrast to previous measurements of the constant electrical field in near space, where only a single component of the field's total vector was measured, the "Cosmos-484" satellite carried instruments that enabled it to measure the total vector. In addition, it had a nearly circular orbit, whereas the two satellites previously used to make measurements did not. The authors present the results obtained with the "Cosmos-484" and draw the following conclusions: 1) all evidence indicates that the polar cap is a separate physical area as far as the presence of charge particles and the magnitude and direction of the constant electrical field are concerned; 2) in the prenoon hours there are several zones that are related to different directions of the electrical field; 3) the existing model of magnetospheric plasma convection can be refined by allowing for the total horizontal component of the constant electrical field; 4) the (Kharang) discontinuity can now be traced up to latitudes of 60-80°. Figures 2; references 18: 5 Russian, 13 Western.
[100-11746]

UDC 523.72:550.383

RELATIONSHIP OF COMPONENTS OF INTERPLANETARY MAGNETIC FIELD'S VECTOR TO VARIATIONS IN GEOMAGNETIC FIELD IN HIGH LATITUDES OF NORTHERN HEMISPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 20, No 6, Nov-Dec 80 (manuscript received 4 Apr 79) pp 1073-1083

AFONINA, R. G., BELOV, B. A., LEVITIN, A. Ye., MARKOVA, M. Yu., FEL'DSHTEYN, Ya. I. and FISKINA, M. V., Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] Using data obtained by 14 observatories in the auroral and subauroral zones from May to August 1968, the authors attempt to correlate the components of the interplanetary magnetic field's vector with variations in the Earth's geomagnetic field. They find some correlation between the vector's B_y and B_z components and the variations, but none for the B_x component. After performing a correlational analysis from several viewpoints (latitude, time of day, season), they constructed a model (previously published) that makes it possible to determine the average hourly values of the geomagnetic field's vector on the basis of the average hourly values of the interplanetary magnetic field's B_x, B_y and B_z

components for part of the period mentioned above. Figures 8; references 4: 3 Russian, 1 Western.
[100-11746]

UDC 550.388.2

EVALUATING CONTRIBUTION OF IONOSPHERE'S REGULAR COMPONENT TO PHASE PATH OF RADIO WAVES EMITTED BY ARTIFICIAL EARTH SATELLITES, ACCORDING TO F2 LAYER'S PARAMETERS, IN RADIO INTERFEROMETER OBSERVATIONS WITH SUPERLONG BASE LINES

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 20, No 6, Nov-Dec 80 (manuscript received 12 Feb 80) pp 1109-1111

ZIMOVSKIY, V. F., Main Astronomical Observatory, USSR Academy of Sciences

[Abstract] In radio interferometer observations with superlong base lines, the ionosphere's effect on the radio waves' phase path can be eliminated by multi-frequency reception or by calculating the phase incursion according to the known altitudinal distribution of the electron concentration. Since the latter can sometimes not be determined in detail, evaluating the ionosphere's contribution from data obtained by a network of ionosphere stations is a matter of considerable interest. The author uses semiempirical models of the ionosphere and the results of several experiments in an attempt to do this. After setting up the mathematical apparatus and using the experimental data, he concludes that the accuracy of the evaluation of the ionosphere's effect (based on the F2 layer's parameters) depends essentially on the altitude of the satellite. Figures 3; references 7: 4 Russian, 3 Western.
[100-11746]

UDC 521.31

DETERMINATION OF GEOSTATIONARY SATELLITE ORBITS BY METHOD OF APPARENT MOTION PARAMETERS

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian Series 1, No 1, Jan 81 (manuscript received 12 Jun 80) pp 95-99

BYKOV, O. P.

[Abstract] Highly accurate satellite photographs taken at a single observation point can be used to determine the orbits of geostationary satellites if the following orbital parameters can be determined: the satellite's two apparent equatorial coordinates, the angular topocentric velocity and its position angle, the satellite's angular velocity and the curvature of the observed section of the trajectory, all of which values are calculated for the average moment of the

observations. The first four are necessary for the determination of circular orbits, while the last two must also be used when determining elliptical orbits. The author discusses an example that demonstrates the possibilities of this method and concludes that the best set of photographs is a series of 15-20 of equal accuracy, taken over a 60-90 minute interval. Figures 3; references 11. [124-11746]

UDC 523.755

JOINT SOVIET-FRENCH INVESTIGATIONS OF SOLAR CORONA: 2. PHOTOMETRY OF SOLAR CORONA ON 30 JUNE 1973

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 58, No 2, Mar-Apr 81 (manuscript received 15 Feb 80) pp 376-382

VSEKHSVYATSKIY, S. K., DZYUBENKO, N. I., IVANCHUK, V. I., POPOV, O. S., RUBO, G. A., KUCHMIY, S., KUCHMIY, O. and SHTEL'MAKHER, G., Kiev State University and Paris Astrophysical Institute

[Abstract] The authors present the results of observations made during the total solar eclipse of 30 June 1973 by Soviet and French expeditions working in the cities of Atar, Mauretania, and Moussoro, Republic of Chad, respectively. They give a brief description of the instruments and observation conditions, as well as the materials that were obtained, then discuss the corona's integral brightness. Figures 6; references 23: 7 Russian, 16 Western. [125-11746]

UDC 523.164.32+523.75

POSSIBILITY OF PREDICTING SOLAR FLARES ON BASIS OF RADIO-FREQUENCY EMISSION CHARACTERISTICS

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 58, No 2, Mar-Apr 81 (manuscript received 8 Feb 80) pp 393-402

KUZNETSOV, V. D., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The author describes an attempt to correlate preflare radio-frequency emission with the appearance of solar flares. The problem consists of three stages: 1) detection of a current layer in the solar atmosphere; 2) determining the layer's parameters; 3) predicting the probability of the onset of a flare and its parameters and aftereffects. The solution may involve radio-frequency observations in the millimeter and centimeter bands, since there appear to be changes in these emissions before a flare, although the work done in this area is only preliminary and primarily theoretical. Figures 4; references 23: 13 Russian, 10 Western. [125-11746]

UDC 539.1.074

ELECTRON AND PROTON SPECTROMETER FOR SATELLITE MEASUREMENTS IN EARTH'S MAGNETOSPHERE

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 3: FIZIKA, ASTRONOMIYA in Russian Vol 22, No 1 Jan-Feb 81 (manuscript received 27 Feb 79) pp 91-95

MINEYEV, Yu. V. and SPIR'KOVA, Ye. S.

[Abstract] Satellite measurement of electron flows in the Earth's magnetosphere is still in its infancy because of the lack of a sufficiently effective method for measuring them against the background of intensive proton flows. However, the development of semiconductor production techniques has made it possible to create an effective spectrometer for the registration of low- and medium-energy electrons. This spectrometer is a system of semiconductor detectors consisting of thin dE/dx- and thick E-detectors placed next to each other. It is almost 100 percent efficient in registering low- and medium-energy protons. The authors describe the layout of the spectrometer and its operation and state that it has been used in a satellite in the "Interkosmos" series. Figures 5; references 4.
[78-11746]

UDC 550.388.2

ANALYSIS OF SOME CONFIGURATIONS FOR FLIGHT TO SATURN

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81
(manuscript received 17 Mar 80) pp 226-231

GEORGIYEV, K. G. and PAPKOV, O. V.

[Abstract] Three possible flight trajectories from Earth to Saturn are analyzed: 1. Direct Earth to Saturn mission; 2. Using the perturbation from a Mars flyby; 3. A flight utilizing the perturbation from a repeat flyby of the earth itself. The possible timeframe for all such missions runs from 1981 to 2000. The most promising is the third variant, i.e., an Earth--Earth--Saturn flight. The first two suffer from the drawbacks of excessive energy or time requirements respectively. The Earth flyby involves the initial insertion of the spacecraft into an intermediate heliocentric orbit followed by entry into a trajectory meeting the Earth, then a flyby of the Earth with a possible powered phase, and thereafter the subsequent flight to Saturn. The orbital insertion around Saturn requires a braking impulse. The advantages of the Earth flyby are: 1. A reduction in the energy expenditures required to reach Saturn by 0.90-1.67 and 1.18-1.93 km/sec respectively as compared to the direct flights for trajectories with a total time of 6 and 7 years; 2. The stability of the total energy and time requirements of the trajectories (the difference in the total energy requirements over the 15 year range of such possible launches does not exceed 500 m/sec); 3. The stability of the boost impulse from the Earth, which amounts to about 4.5 km/sec, i.e., close to the impulse needed to reach Mars or Venus. Taking into account the powered phase from satellite orbit, this leads to an even greater energy advantage over direct flights as well as a simplification of the plan for leaving orbit. It is noted that the power needed to execute the Earth--Earth--Saturn maneuver is equal to or even somewhat less than that needed to reach Jupiter via direct trajectories. Figures 3; references: 2 Russian.
[121-8225]

UDC 523.042:523.42

PHOTOCHEMISTRY OF VENUSIAN ATMOSPHERE AT ALTITUDES ABOVE 50 KM.: II. CALCULATION RESULTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81 (manuscript received 20 Jun 80) pp 261-278

KRASNOPOL'SKIY, V. A. and PARSHEV, V. A.

[Abstract] Data from the Pioneer and Venera-12 probes are used to construct a model of the neutral composition of the atmosphere of Venus at altitudes of 50 to 200 km. The model determines the concentrations of CO_2, H_2O, HCl and SO_2 photolysis products as a function of altitude and overcomes certain deficiencies of its predecessors, e.g., the artificial separation of sulfur and chlorine compounds. Particular attention is devoted to the CO_2 and CO equilibrium at altitudes of 50 to 100 km: A bend detected in the CO concentration curve as a function of altitude is explained in detail. There is good agreement between the theoretically predicted HCl, SO_2 and sulfur concentration curves and the probe data. Relative water vapor content is varied at the lower boundary to optimize agreement with the experimental data; in this case, extremely small variations in $[H_2O]$ at 50 km led to substantial changes in the H_2O, H and other H_2O photolysis product contents in the atmosphere above the clouds. It is shown that for a specified relative content of $f_{SO_2} = 1.3 \cdot 10^{-4}$ at 50 km (from gas chromatographs in the probes), the best agreement of the model with the data of ground observations of H_2O bands in the upper region of the clouds is obtained at $f_{H_2O} = 1.9 \cdot 10^{-4}$ at 50 km; this is confirmed by water measurements from the Venera vehicles. The extensive graphs include: the concentration of sulfuric acid in the aerosol phase as a function of altitude; the O_2 breakdown and formation reactions as a function of altitude; the photolysis of the abovementioned compounds plus H_2O_2, O_3 and Cl_2 as a function of altitude; the breakdown and formation reactions for the active forms of chlorine and hydrogen; the formation and destruction of atomic hydrogen in the upper atmosphere and the processes of the formation of $O_2(^1\Delta_g)$ and its concentration as a function of altitude. Molecular oxygen forms a layer at 80 to 85 km with an overall content of $3.7 \cdot 10^{19}$ cm^{-2}. The model results do not contradict the presence of O_2 in the cloud layer, although its occurrence there is difficult to explain and is doubtful. The observations of O_2 1.27 micrometer luminescence is explained; this luminescence occurs in a layer 7 km thick with a maximum at 98 km. The $O(^1D - ^3P)$ 6,300 Å luminescence is found to be concentrated in a 30 km thick layer with a maximum at 160 km. In the concluding discussion of the photolysis rates as a function of altitude, it is noted that a group of substances are found which decompose only with the action of hard UV radiation (CO_2, HCl, O_2 and H_2O); another group (SO_2, H_2O_2, Cl_2 and O_3) undergoes photolysis with moderate and soft UV radiation at a rate on the order of 10^{-4} to 10^{-2} sec^{-1}, falling off sharply at 60 km due to strong SO_2 absorption. Figures 15; references 42: 10 Russian, 32 Western.
[121-8225]

UDC 523.07:523.165

MANIFESTATIONS OF SOLAR COSMIC RAY ACTIVITY ON GROWTH BRANCH OF 21ST CYCLE, AS REGISTERED BY 'METEOR' ARTIFICIAL EARTH SATELLITE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 20, No 6, Nov-Dec 80 (manuscript received 12 Jul 79) pp 977-981

PEREYASLOVA, N. K., NAZAROVA, M. N. and PETRENKO, I. Ye., Institute of Applied Geophysics, Main Administration of Hydrogeological Services

[Abstract] The authors present data on 22 occurrences of solar cosmic rays in the 1977-1978 period, as registered by a "Meteor" artificial Earth satellite. Of these 22, which occurred from 17 September 1977 to 29 November 1978, only 5 featured significant flows of solar cosmic rays at stratospheric altitudes: 19 and 24 September and 22 November 1977 and 7 May and 23 November 1978. By tabulating the available data on time of maximum solar cosmic ray emission, cosmic ray flux and amplitude of asymmetry at the maximum, sign of the interplanetary magnetic field sector and contemporaneous solar flare activity, the authors conclude that these occurrences are caused by flares in the northern hemisphere of the Sun. Basically, these occurrences were characterized by significant proton flows, stable spectra, protracted asymmetry and typical irregularities in the form of the polar, auroral and cusp-type peaks. Figures 3; references 8: 4 Russian, 4 Western.
[100-11746]

UDC 523.74:523.72

RELATIONSHIP OF CONFIGURATION OF INTERPLANETARY SHOCK WAVES TO POWERFUL, ISOLATED FLARES WITH PROTON PHENOMENA

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 20, No 6, Nov-Dec 80 (manuscript received 9 Apr 79) pp 982-989

IVANOV, K. G., YEVDOKIMOVA, L. V., MIKERINA, N. V. and KHARSHILADZE, A. F., Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] The authors develop some propositions in favor of the theory that the source of energetic solar protons ($E_p \geqslant 1$ MeV) after a powerful ($\geqslant$ 2F), isolated (by at least 2.5 days from other flares) flare can be the shock layer between the leading shock front and the flare ejecta's boundary. A previous assumption that they attempt to disprove is that the shock wave is spherically symmetrical. They develop a model on the assumption that it is not and then test it against experimental data. Out of 57 cases, the coincidence of expected and realized phenomena is quite high (46, or 80%), so the authors feel justified in saying the configuration of shock waves from powerful, isolated flares affects

the propagation of energetic protons in interplanetary space and, in particular, the appearance (or lack thereof) of protons near Earth. Figures 5; references 18: 12 Russian, 6 Western.
[100-11746]

UDC 621.031

SLOW ROTATIONS OF HEAVENLY BODIES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 24 Sep 79) pp 26-33

BELETSKIY, V. V.

[Abstract] The evolution of the rotational motion of a heavenly body is usually studied with special evolutionary variables, one of which is "fast" while the others are "slow." The necessary and sufficient conditions for "slowness" are that the disturbing moments be small and that the body's ellipsoid of inertia be close in shape to a sphere. The evolution is then determined by a power function that the author converts to an average form that determines approximate motions of a body involving only slow evolutionary variables, which motions are called "slow rotations." He then checks his results with illustrations involving magnetic, gravitational and aerodynamic disturbances. References 8: 6 Russian, 2 Western.
[87-11746]

UDC 550.388:523.42

NONUNIFORMITY OF SOLAR WIND ON LINES OF COMMUNICATION WITH 'VENERA-9' AND 'VENERA-10' STATIONS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 7 Sep 79) pp 114-119

VASIL'YEV, M. B., VYSHLOV, A. S., KOLOSOV, M. A., KOLCHEYEV, G. N., SAVICH, N. A. and SAMOZNAYEV, L. N.

[Abstract] The authors present the results of measurements of the solar wind that were made during the flights of the "Venera-9 and -10" stations by a dispersion interferometer operating in the decimeter ($\lambda_1 \approx 32$ cm) and centimeter ($\lambda \approx 8$ cm) bands. The measurements were made during the period from 3 October 1975 to 15 June 1976. The temporal scales of the irregularities ranged from 0.5 s to about $4 \cdot 10^3$ s, with their intensity increasing as the lines of communication

neared the Sun. The authors derive a relationship for the change in the integral electron concentration that shows it decreasing more rapidly as the distance from the Sun increases. There is also a high degree of correlation of changes in the integral electron concentration for the two lines of communication, which were about 10,000 km apart. Figures 7; references 17: 9 Russian, 8 Western. [87-11746]

LIFE SCIENCES

EFFECTS OF WEIGHTLESSNESS ON THE HUMAN ORGANISM

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 81 p 40-41

/Article by I. Pestov, doctor of medical sciences, State Prize laureate: "Through the Weightlessness Barrier"/

/Text/ The Soviet Union has begun to operate orbital stations. Multi-month watches on the part of cosmonauts have become a commonplace phenomenon and are having a huge scientific and economic effect.

The specialists in space medicine, who have done everything possible so that the cosmonauts can work long and fruitfully in orbit, deserve a great deal of credit for the achievements gained in manned cosmonautics. For its development of methods and equipment preventing protracted weightlessness from having a deleterious effect on the human body, a group of Soviet scientists has been awarded the USSR State Prize.

This article is concerned with what is now known about the effect of weightlessness on the human organism.

In making an orbital flight, man is not simply lifted several hundred kilometers above his native planet -- he breaks away from the conditions under which he was formed and lives permanently. The new medium into which he penetrated 20 years ago is unique and foreign to his nature. The uniqueness is due to its lack of gravity, a factor which is very important for every living and growing thing on Earth. Man began to conquer space, a world without gravity, very cautiously. The first scouts in orbit were various biological objects, including our four-legged friends.

The first real obstacle cosmonauts encountered in space was vestibular malfunction accompanied by seasickness and spatial disorientation. In the initial phase of spaceflight, it turned out that every third cosmonaut suffered such disorders.

It is important to mention a curious fact here: there proved to be no reliable correlation between a person's susceptibility to seasickness on Earth and the probability of the appearance of vestibular malfunction in him during spaceflight. A person can be seasick on Earth and feel fine in space, and vice versa.

In order to overcome this malfunction, at the present time we are using -- with a certain degree of success -- a system of preflight training of the vestibular

apparatus, as well as training for an "antiorthostatic" position of the body (that is, a position in which the head is below the feet).

Fortunately, vestibular malfunction during spaceflight is of a temporary nature and lasts, as a rule, only 2-3 days, rarely longer, before it passes away.

As the length of spaceflights increased, so did the number of problems arising before the specialists. As it turned out, vestibular malfunction is only part of the organism's reaction to the unusual conditions of a world without gravity.

Right now, 20 years after Yu.A. Gagarin's flight, the mechanism of the effect of weightlessness on the basic systems of the human organism is quite clear. However, questions concerning weightlessness's possible effect on cells, the reproductive organs and the intimate processes of vital activity require further study.

In popular scientific articles one can find the expression, "Weightlessness -- Enemy Number One." In space, man has more than enough enemies: radiation, vacuum, huge temperature gradients. However, this expression is true in the sense that in comparison with the other flight factors, weightlessness causes living organisms the most trouble and, at the same time, creates serious complications in the overcoming of its unfavorable consequences.

One would think that in space the body is freed from all the difficulties that are related to terrestrial gravity. However, not just any lightening is a blessing. Weightlessness means a reduction in the load on the muscles, a lessening of the load on the skeleton, and the absence of hydrostatic blood pressure. As a result of the relieving of the hydrostatic blood pressure, overfilling of the vessels in the upper part of the body takes place. This is accompanied by a feeling of heaviness in the head, a headache, and a spinning sensation in the head. The congested blood contributes to seasickness and activates vestibular malfunction. If this went on all the time, man would not be able to make flights into space. However, in response to unusual conditions the body engages its adaptive mechanisms.

As a designer, nature is a genius. In the human body she has provided reserves, taken the trouble to duplicate a series of functions, and installed in it the ability to substitute for lost properties and increase reserves and reliability by means of training. However, nature is not wasteful and does not manifest any striving toward redundant solutions.

As soon as the load on the skeleton is reduced, calcium starts to wash out of the bones and they lose their strength. If there is no load on the muscles, such as when the force of gravity is being counteracted, they decrease in volume. Since the cardiovascular system is not charged with assignments related to the constant supplying of the body's energetics with oxygen and nutritive substances for opposing terrestrial gravitation, poor conditioning of the heart develops and its productivity decreases. There are also changes in metabolic processes. It is obvious that we could put up with this if man did not, sooner or later, have to return to Earth and the readjustments in his body do not go too far and threaten his health. The encounter with overloads during landing and with terrestrial gravity does not promise anything good to a weakened body. Man in space needs some kind of equivalent of those loads to which his body is accustomed on Earth. This is the only way to combat weightlessness. But how do we do this, since nothing weighs anything in space and a man floats freely in the compartments of an orbital station?

K.E. Tsiolkovskiy thought about this a long time ago. He suggested artificial gravity. If spin is imparted to a spacecraft, then because of the radial acceleration there appears an overload that is close, in its content and effect on the body, to the force of gravity.

True, we run into serious difficulties in connection with this. For instance, in order that the artificial gravity not cause vestibular malfunction, the space system must have a large radius of rotation on the order of tens and hundreds of meters. This complicates the design of the system substantially. Besides this, life in a constantly rotating station involves large complications related to the onset of Coriolis accelerations when people move. In this case, it would be impossible to conduct research, experiments and observations under weightless conditions.

Since the complex of facilities for prophylaxis against the unfavorable effect of weightlessness that has now been developed satisfies the practical needs of cosmonautics, the question of creating artificial gravity in spacecraft has been asked prematurely. The existing complex of prophylactic means is based on an effort to create in weightlessness the equivalent of the weight load on the bone and muscle system and to eliminate the consequences of the abnormal distribution of blood in the body that is related to a lack of weight and hydrostatic pressure.

It is possible to create a constant, static load on the muscles and skeleton with the help of rubber braces that run along the body. The load suits that cosmonauts now use during flights operate on this principle.

A complex trainer with a "running track" makes it possible to obtain a dynamic physical load in a station. A cosmonaut dressed in a load suit stands on the "running track" and is held on it by a tightening system. As a result, the suit distributes the forces on the waistband and the shoulders, while the legs are pressed to the track. This makes it possible to walk, run and jump with a great expenditure of physical effort, thereby maintaining the coordination of the important motor skills.

A space trainer of another type is the veloergometer, with the help of which it is possible to dose out a wide range of physical loads, thereby preventing the development of deconditioning, including that of the cardiovascular system.

In order to simulate intravascular hydrostatic blood pressure, we use devices that produce lowered pressure in the lower half of the body and facilitate the movement of blood to the legs.

Our arsenal of prophylactic measures also includes instruments for electrostimulation of the muscles, water-salt loading and pharmacological preparations.

The rational organization of the cosmonauts' labor, rest and daily life has an important role in prophylaxis of the unfavorable consequences of protracted spaceflight.

Large groups of scientists, designers and engineers have taken aim at overcoming the barrier of weightlessness. Cosmonauts have been active participants in this work.

All of this, as a whole, made it possible to enlarge the framework of the permissible duration of spaceflight and gradually reach the periods we see today. As is well known, they are now numbered in months, and not just a few of them.

For the future, the amount of time that has been achieved will probably prove to be inadequate. Manned flights for the investigation of the planets can last for years. The work of crews in stations in orbit around the Moon, Venus, Mars and Jupiter can last for just as long.

What are the predictions relative to flights of such duration? They can be based on a generalization of our preceding experience, an analysis of tendencies, the investigation of analogs. Our experience in manned flights lasting up to half a year that have already been made indicates that apart from the well known manifestations of fine adaptation to weightlessness and the development of asthenization processes related to the phenomena of "disuse" or "atrophy from inaction," no unexpected or qualitatively new changes take place in the human body. It goes without saying that if corrective, controlling measures are not used with respect to these changes, they can reach levels that are dangerous to health and cause serious complications, in particular, in the process of readaptation or adaptation to terrestrial conditions after the end of a flight into space. However, if the stipulated volume of prophylactic measures is carried out properly and the work and rest regimes are observed, extended flights can be borne as easily as those of shorter duration.

According to most indicators of the functioning of the cardiovascular system, blood formation, the metabolism and the muscle support system, a stable equilibrium state is achieved that gives no grounds for assuming the appearance of unexpected and unfavorable tendencies in relation to a subsequent extension of the duration of flights into space. Psychological difficulties will apparently be of the most substantial importance, although even they do not appear to be insurmountable.

Apart from this, factors limiting the duration of spaceflight can be illnesses, which on a long flight can increase the effect of asthenization and the lowering of the body's resistance and demineralization of the bone tissue that is related to the slow but steady loss of calcium.

Unfortunately, it is not possible to establish temporal limits for the appearance of these limitations on spaceflight on the basis of the factual data available at the present time.

Considering that an active motor regime is an important factor in longevity, it can be assumed that the hypodynamia that constantly and invariably accompanies weightlessness serves as a prerequisite for the development of premature aging. However, this hypothesis has not yet been confirmed by experimental observations.

With due consideration for these stipulations, it can be said that flights ranging in duration from a year to several years are possible in principle, but require the presence in the crew of medical personnel, and on the ship of special equipment for diagnostic and medical-prophylactic assistance. It is also necessary to utilize an extensive complex of measures that facilitate the readaptation of the body to terrestrial conditions after the completion of such flights.

Judging by the results of spaceflights that have already been completed, for the body of a grown man the recuperation of the structure and functions is successful,

although it does take some time. Less clear is the answer to the question of how reversible would be the losses caused by weightlessness in a young, developing body in which the formative role of gravity would not be able to be manifested to the same degree as in those of the same age on Earth. It can be assumed that in this case the development process would proceed with deviations in comparison with terrestrial standards that might be consolidated in features of the body's structure and functions that would complicate the subsequent process of adaptation of a young body to terrestrial conditions. Although this question is only of theoretical significance for the future development of cosmonautics at the present time, it probably should be studied on the basis of experiments with animals.

In the 20 years that have passed since Yu.A. Gagarin's historic flight, Soviet space medicine has accumulated a great deal of experience, enriched science with important factual data and theoretical propositions, and made a notable contribution to the development of Soviet cosmonautics. Engendered by the demands of scientific and technical progress, in the future it will continue to carry out its high and humanistic mission, assisting with great success man's conquest of outer space.

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CSO: 1866/82

FOOD AND NUTRITION FOR LONG MISSIONS IN SPACE

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 1, Jan 81 pp 42-43

[Article by I. Popov, candidate of the medical sciences: "Nutrition on a Long Space Flight"]

[Text] Many new problems have come up with the increase in the duration of manned space flights. Concerns have also increased markedly among specialists handling the nutrition of the cosmonauts. It has been necessary to obtain more precise data on the needs of the organism for the chemical substances obtained from foods. For this, research has been conducted on the ground, the experience of previous missions has been taken into account and the results of medical, biological, biochemical and physiological experiments performed in space have been used. This has made it possible to refine the food rations and bring them into line with the needs of the cosmonauts' organisms and the energy expenditures. As a result, the calorie content of the daily food ration of the crews of the "Salyut-6" orbital station was increased by 300 kilocalories and now amounts to 3,200 kilocalories; products have been incorporated in it which promote the normalization of the metabolism under conditions of physiological tension (stress).

With the start of long missions, even greater attention is being devoted to the preservation of good quality and taste of the products on-board the station. For this, their packaging has been improved, they are subjected to preliminary processing using more sophisticated technological procedures, and special substances are introduced in them, in particular, antioxidants.

The cosmonauts began to make wider use of dehydrated products with the installation of a water recovery system from the atmospheric moisture in the "Salyut-6". This has made it possible to increase the stock of food on-board and diversify the assortment.

The crews of the "Salyut-6" heat food not only in dispenser tubes, but also canned meats and bread. The cosmonauts now have one to two hot dishes and it has become possible to use the food rations for a longer period of time.

The change in the taste perception of cosmonauts in flightagainst the background of fatigue was subjected to a special study. As a result, the scientists came to the conclusion: in order to improve the appetite under such conditions, it is necessary to add different spices and condiments to the products stored on-board the station.

As early as the preparation for the first orbital missions, the problem of providing the crews of spacecraft with food and water was numbered among the major problems. And this is no accident: even under ordinary conditions, high quality nutrition in terms of the composition and conditions plays an important part in maintaining man's health and work capability. And with stressful physical and intellectual work, when various unfavorable environmental factors act on the organism, the value of nutrition increases even more.

In the early stages, the practical solution of these problems was facilitated by the short term nature of the mission. As applied to the conditions of living in spacecraft designed for missions of up to a few days, a system was designed for the on-board nutrition which was maximally simple in terms of equipment. It included a stock of food products in the form of daily rations, two containers: for their storage and to collect the food leftovers as well as packages and adapters to facilitate the preparation and eating of the food. Its major component is the daily food rations, The size and weight characteristics, as well as the specific features of the set of products, the consistency and packaging in the daily rations were determined by the structure and composition of the individual components of the nutritional system,

Requirements were placed on the daily rations which have not lost their importance up to the present time. They should primarily correspond to the energy requirements of the cosmonauts during the mission, have full compositional value and maximum assimilability of the major nutritional substances: proteins, fats, carbohydrates, mineral compounds and vitamins. It is necessary that the food maintain its good quality under storage conditions at 20 to 25 °C and stay safe throughout the entire mission, have sufficiently good taste qualities, which provide for its maximum utilization even when the appetite is reduced, and not become boring. Moreover, it should be convenient for intake in weightlessness and not require additional culinary processing, heating, cutting or special dishware.

The combining of these and other qualities in one daily packet is far from a simple matter, all the more since there are no analogs used under ground conditions. Only the flight rations for a flight crew, introduced into supply in 1958 and intended for aircraft crews during flights lasting more than four hours were the closest of all to the requirements enumerated above. The experience in putting it together was also used for the space ration.

The daily ration of the cosmonauts who flew in the "Vostok" and "Vostok-2" ships contained about 2,800 Kcal, including 100 grams of protein, 118 grams

of fats and 308 grams of carbohydrates. In terms of calorie content, such a ration is recommended under ground conditions by the Institute of Nutrition of the USSR Academy of Medical Sciences for persons whose work does not require substantial physical effort and is therefore accompanied by a lifestyle with a small amount of motion (the first profession group). The balance in the ratio of proteins, fats and carbohydrates was 1:1:3.

For a comparison, we recall that the flight ration in jet aviation is of high calorie content, something which is due to the considerable energy stress of the work of a flight crew. Because of the use of exclusively preserved products which are not vitamin enriched, as well as the elevated consumption of vitamins by cosmonauts, supplied in addition to the natural products in the dispenser tubes was a multivitamin drop containing vitamins C, B_2, B_6, P, PP, E and pantothenic acid.

The energy expenditures of test subjects fluctuated from 1,754 to 2,549 Kcal per 24 hours (2,000 Kcal on the average) during modeling of the flight work and rest conditions on the ground, something which guaranteed that a ration of 2,800 Kcal would be adequate, and even have a definite reserve.

Besides products in dispenser tubes, samples of solid consistency products (pieces of bread, smoked sausage, etc.) were placed on board the "Vostok" and the "Vostok-2" ships in polyethylene packets for an experimental check of the possibility of eating them in weightlessness. During the mission of Yu. Gagarin, there was essentially no necessity for additional food intake. However, for the further development of space nutrition, such an experiment was extremely important. For this reason, in the 30th minute of the mission, Yuriy Alekseyevich ate and drank in accordance with the program. His conclusion that "everything went the same as for us on the earth", became not only the first evidence of the possibility of taking in, chewing and swallowing liquid and solid food in weightlessness, but also opened up the road for the use of products of different consistencies in subsequent flights.

Daily rations which were more diverse in terms of their composition were developed on the basis of studies during the first missions. Products which were used on earth in liquid or puree form were put in dispenser tubes: soups, cottage cheese as well as drinks: coffee, cocoa and juices. Snack products though, bread products, appetizers as well as sweet pastry products and fruits were packaged in film packets made of viscotene. Some of the products were vacuum packed to preclude contact with the oxygen of the air and better protection against contamination. The cosmonauts successfully used these rations during missions on the "Vostok" and Voskhod" type ships.

However, the rations which were developed had limited shelf lives without a refrigerator (up to five to six days). For example, meat products in packets had to be prepared directly prior to flight. They were delivered in cooled

containers to the spaceport, where they were placed in a refrigerator. If they were not loaded on the ship in two to three days, then it was necessary to prepare and deliver a fresh batch of packets.

For the cosmonauts who flew the missions in the "Soyuz" ships, new daily food rations were created, which consist of products which can be stored for a long time at room temperature without a refrigerator. Pureed and liquid products in dispenser tubes have proved themselves good after storage: soups, juices and drinks. The assortment of packets of bread products which become stale slowly was expanded (wheat, table and Borodinskiy bread). The bread products were baked in the form of small "one bite" rolls. This prevented the appearance of crumbs.

Meat products (ham, steak, veal) were prepared in the form of meats preserved in metal cans. The "Rossiyskiy" processed cheese was also packaged in the same way. The sweet products included chocolate candy, prunes with nuts and honey gingerbread (all in film packages). Some of the products in the form of briquettes were covered in edible film. The rations had a menu planned for three days. Food was to be taken four times a day.

The rations of the cosmonauts who flew in the first "Soyuz" ships also included products made of dehydrated boiled meat which were packaged in film packets and vacuum packed. However, their use made a negative impression on the cosmonauts. For this reason, they were subsequently replaced by conventional canned meats. Other dehydrated products (cottage cheese briquettes with black current puree, milk concentrates and cakes) were sucessful and have been used up to the present time.

Starting with the mission of the "Soyuz-9", the cosmonauts started to heat the first meals and drinks in the dispenser tubes up to 60 to 70 °C.

With the design of the "Salyut" orbital station, the living conditions improved and the system of nutrition was further developed. There is a buffet table on board the station for taking in the food, as well as a set of table accessories, a food heater, facilities for sanitary cleaning of the table accessories and bags for collecting the food leftovers and packaging. Because of the implementation of physical training exercises during the mission as a means of combatting the negative consequences of weightlessness, the calorie content of the rations were increased up to 3,200 Kcal.

The cosmonauts P. Popovich and Yu. Artyukhin on the "Salyut-3" were the first who tested dehydrated products, restored during the mission using recovered water. These experiments were successfully continued by the crews of the "Salyut-4" station.

The incorporation of dehydrated products into the rations was due to the effort to reduce their weight, increase the shelf lives and improve the nutrition of the cosmonauts through the use of products which differed little

from natural products in their taste qualitiess. Dehydrated products now comprise up to 10 percent of the food rations.

The dehydration of the products is accomplished by means of freeze drying. The finished main courses and appetizers, as well as juices, are subjected to rapid freezing, and then dried out in a vacuum. As a result, the water is removed from them, avoiding the liquid phase. No more than 2 to 3 percent water remained in the products. The product is immediately packaged in special film packets which are vacuum exhausted.

The cosmonauts in the orbital missions prior to the "Salyut-4" were fed exclusively using stocks loaded on the craft at launch. The second crew of the "Salyut-4" took along an addition reserve of products having a limited shelf life, as well as bread, coffee and tea for the first time in the transport ship.

Subsequently, the delivery of fresh food rations to the orbital station along with the next crew became widespread. This is now being primarily accomplished to an even greater extent by means of the unmanned "Progress" transport ship.

During long missions, the cosmonauts become even more discriminating in their eating and they place especially high requirements towards the end of the flight. This is readily explainable: no matter how diverse the set of products, something new and fresh is desired. Fatigue also has an impact. For this reason, they are now supplied with all possible seasonings. They are included in the dispenser tubes and dehydrated packets. These are the "Moldova" seasonings, sweet cranberry-apple sauce, dehydrated with horseradish.

The cosmonauts voiced the wish to have fresh vegetables and fruit on board the station, so that the food would taste more like freshly prepared dishes, rather than canned ones. They wanted the products to have improved packaging: easily opened cans, as well as packets more convenient for use with conventional and dehydrated foods, so that there would be fewer protective coverings.

Unfortunately, not all of the requests can be met as yet. But the search is continuing; and primarily in the direction of increasing the taste of the food products. Individual tastes of the crew members are being taken into account. Food which does not appeal to the cosmonauts is replaced by other food, of equal nutritional value.

The water supply system on board the spacecraft now functions in conjunction with the food system, since cold and hot water is needed to restore the dehydrated products. The store of drinking water in the orbital station is produced at a design rate of up to two liters per man per 24 hours.

Thus, the on board food and water supply systems in our spacecraft and orbital stations are being continually developed and improved in line with the new tasks of space flight.

8225
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FEOKTISTOV ON SPACE CONSTRUCTION, ORBIT-TRANSFER VEHICLE

Moscow PRAVDA in Russian 9 Jun 81 p 3

/Article by Konstantin Feoktistov, USSR pilot-cosmonaut, doctor of technical sciences, professor: "To Future Orbits"/

/Text/ The scheduled program of operations with the "Salyut-6" has been completed. There were 28 cosmonauts from the socialist countries who worked in the station, 34 dockings took place, and a vast number of scientific investigations and technical experiments were performed, along with observations and photographing of the Earth, in the interest of our national economy. On the whole, this was an important new step along the road to the conquest of near-Earth space.

This is necessary for the further expansion and development of man's activity in space. The solution of such problems as practically unlimited intercity communication operating on the level of normal city telephone communications, the transmission of television programs through repeater satellites directly to television receivers, and the lifting into near-Earth orbits of radio and optical telescopes, plants for the production of superpure semiconductors, medical preparations and other goods, and space electric power stations requires the construction of huge structures: gigantic antennas, solar batteries, structures with dimensions of tens and hundreds of meters and even kilometers. Many of these structures must be built in a geostationary orbit at an altitude of about 36,000 kilometers.

These and similar projects have already been placed on our agenda by the logic of the development of cosmonautics. However, a number of serious technical problems have to be solved before they can be practically realized. What are we talking about here?

For example, it is necessary to create light and cheap solar batteries of the film type, so that each kilowatt of power will require no more than 2 kilograms of battery weight. There are also questions concerning the creation of even more economical transport rockets and facilities for transporting goods from low near-Earth into geostationary and other high orbits. Here, obviously, we need interorbital ships using solar energy and electric-reaction engines as their means of propulsion.

The process of mastering near-Earth space has come to life in our time. In order to do it, it was necessary to create a base in orbit, supply it, have the

capability to replace specialists and study the possibilities of man's staying in weightlessness for a long time and performing the most variegated operations, from delicate astronomical observations to repairing and installing equipment both inside the station and in open space.

The orbital unit of the "Salyut-6" station was a base for the performance of such work. In order that the crew might be changed and the station supplied, it had two docking units for ships and a joint propulsion system that could be controlled in flight. There was also a capability for installing and connecting newly delivered equipment and repairing and replacing individual instruments and assemblies.

The "Soyuz" and "Soyuz T" transport ships delivered cosmonauts to the station and returned them to Earth, while the "Progress" automatic cargo ships supplied it with oxygen, food, water, fuel, additional scientific equipment, spare instruments and so on.

During the operation of the "Salyut-6" we gained a great deal of experience in the rendezvousing, docking and sealed coupling of spacecraft and the transfer of liquids and gasses to the station and we tested the cosmonauts' ability to carry out the most diversified operations. A considerable number of astrophysical, technical and applied (in the interest of the national economy) investigations and experiments were carried out, totaling about 150 different items. Most of them were repeated at least once.

For instance, about 60 astrophysical observations were made, about 13,000 photographs were taken for the purpose of geophysical research and natural resource monitoring, several hundred visual observations accompanied by surveying (about 2,000 pictures) were made, approximately 200 technological experiments on the production of pure materials under weightless conditions were performed, and there were about 900 medical and biological experiments. Manned flights for up to half a year under weightless conditions were realized for the first time, and methods for combatting the effects of weightlessness on the human body were developed and tested successfully. Among other developments were those of an on-board system for cooling to the temperature of liquid helium, an in-flight refueling system and an orbital radiotelescope with an antenna 10 meters in diameter. Orientation accuracy on the order of a few angular seconds was achieved for a spacecraft with dimensions in the tens of meters, television transmission from the Earth to the station was realized, and plates with traces of micrometeorite activity were delivered to scientific laboratories.

Of course, these achievements do not mean that we know everything about space and can treat it as a friend. This new area that is being conquered by man has working conditions that are too unusual and difficult, and our new technology needs repeated and protracted testing under real operating conditions.

It is necessary to continue to amass experience in working in space, testing our research methods, instruments and equipment, improving the conditions for the cosmonauts' vital activities, and increasing our equipment's service life. Thus, step by step we are laying the foundation for the further conquest of space in the interests of our national economy and science.

11746
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SPACECRAFT RENDEZVOUS MANEUVERS

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 6, Jun 81 pp 42-43

[Article by Yu. Avdeyev, candidate of technical sciences: "At the Intersections of Space Roads"]

[Text] The convergence of spacecraft in earth orbit is one of the most complex problems of astronautics, the solution of which is directly linked to the actualization of many projects in the mastery of space. Of the utmost practical interest are matters concerned with rendezvous and soft contact or docking. In this case, it is usually implied that there are at least two spacecraft involved in the rendezvous operation.

In the study of a ballistic scheme for rendezvous, an important place is always accorded the selection of parameters of the assembly orbit. It is recognized that, if the orbit is circular, the rendezvous scheme is simplified and is realized with minimum fuel consumption. This, in turn, enhances the reliability of fulfillment of the whole program. That was the reason for adopting a circular orbit for the "Salyut" stations. The height of the assembly orbit is determined on the basis of flight safety conditions (below the earth's radiation belt) and satisfaction of ballistic lifetime. One also has to take account of atmosphere-induced perturbations which act to slow down the craft. Its orbit will be a spiral bending in towards earth and at some stage in the flight the craft will enter the dense layers of the atmosphere. From a height of 160 km this will occur after several orbits; it will occur after several days from 200 km and after several months from 300 km. This means that, in order to insure the long-term functioning of a station, it is necessary either to put it into a higher orbit or, from time to time, give it an upward push by motor power.

How often must these corrections be made and how much fuel is required? Let's say the station was put into a circular orbit at 250 km. We take the minimum possible flight altitude as 200 km, and we determine the fuel reserve necessary to keep the station within the given altitude range for a year. Eleven pairs of corrections with a total characteristic velocity impulse of 319 m/sec are needed. With a vehicle mass of 20 t about 2000 kg of fuel will be required.

Perhaps the station should be higher at the outset, say 350 km, to ensure the specified lifetime. Calculations show that for a lift from 250 km to 350 km a velocity impulse of 60 m/sec is needed. In this case, the fuel required will be

one fifth of what is needed to maintain station orbit by successive corrections. There is no doubt that such an approach is more advantageous.

Now we'll imagine a launch pad on which stands a fueled rocket with a spacecraft. Where should the rocket be aimed in order to find the station in space. The answer is simple at first glance: Select a time when the station will be flying toward the cosmodrome and, at the proper moment, launch the ship to rendezvous with it. Notwithstanding its seeming simplicity, this plan has two significant defects. Firstly, not only the ship itself ascends to the rendezvous orbit, but also the heavy and bulky last stage of the launch vehicle. From the standpoint of putting a payload into orbit the flight trajectory of the launch vehicle in this case will not always be optimal. Secondly, the rocket, as the controlled mechanism, is subject to numerous perturbations which are hard to allow for and sometimes little-known; and this leads to specific errors in putting it into orbit--errors whose compensation consumes expensive fuel.

In practice, therefore, another rendezvous system which takes more time has been used. The ship is initially put into an intermediate orbit which is lower than the assembly orbit. Then, by a series of successive maneuvers "at the intersections of the space roads", it is eased toward the station into the effective range of their autonomous facilities for getting together. We will take a look at this system.

An indispensable condition of the ship's launching is that it be put into the plane of the station's orbit. This is governed by the selection of the launch time. Otherwise, a considerable amount of fuel is required in order to match up the planes of the orbits. For example, a "Soyuz" uses 300 kg of fuel to make a one-degree change in the inclination of its orbit. A lag of just one second in the launching of a ship necessitates a correction to match orbital planes with an impulse of 0.44 m/sec, and a deviation of one-tenth of a degree in the launch azimuth calls for a 5.5-m/sec impulse for correction.

The ship can be moved from parking orbit to the assembly orbit by using two, three, or more impulses in the remote guidance segment. The two-impulse system is attractive for its simplicity since convergence is brought about by two firings of the engine at diametrically opposite points of the orbit. If necessary, it can be stretched out in whatever manner timewise by keeping the ship in the parking orbit for a specific number of revolutions. This system, however, as in the case of putting the ship directly into the rendezvous zone, turns out to be rather inflexible and doesn't account for the effect of errors in correction and in forecasting motion while going to the rendezvous point. The three-impulse system, though, makes it possible to vary--within defined limits--the ship's flight time to the rendezvous point with the same total fuel expediture by means of its redistribution among the corrections.

Here's an example. Say the orbits of the ship and the station are circular, at 200 km and 300 km respectively. The station is situated ahead of the ship a distance of 5000-10000 km. We will use the following system of transition: The second correction is performed a half orbit after the first, and the third is performed after 11 orbits. In this case, the total remote guidance correction impulse amounts to 58 m/sec. However, it is always possible to find another

combination of three correction impulses spread out over a period of time and adding up to 58 m/sec, which will achieve the rendezvous.

The three-impulse system of remote guidance is an idealized system which does not fully allow for the actual conditions of a flight. In reality, the orbits of the ship and the station will never be truly circular since the earth's gravitational field is off center. It can be a matter merely of the approximation of circular orbits to one degree or another.

The true orbits of ship and station, likewise, are never known with absolute accuracy. Involved here are perturbations which are difficult to allow for due to imprecision of knowledge about the earth's force field, the resistance of the atmosphere and how correction impulses work out, and due to error in orbital measurements from ground stations. On each revolution the ship and station are in the zone of visibility of control and measuring posts for only a limited time. As concerns the potential of ground-based and autonomous facilities, they are not in a position to instantaneously compute and issue appropriate instructions for control. Hence, a certain reserve of time is required for calculations, making decisions and issuing instructions for performance of corrections.

That is why the real-time schedule for executing individual operations introduces a number of substantial adjustments into the idealized remote guidance scheme. But don't think that it loses its value altogether. It doesn't. It serves as a zero approximation in the computations for remote guidance.

In order to compensate for a possible accumulation of errors in controlling and predicting motion, the real-time schedule may include provision for additional corrections. For example, in order to provide for remote guidance on the "Apollo", a standard six-impulse system of corrections was adopted. In other words, the idealized scheme of remote guidance was broken up and subsequently utilized several times.

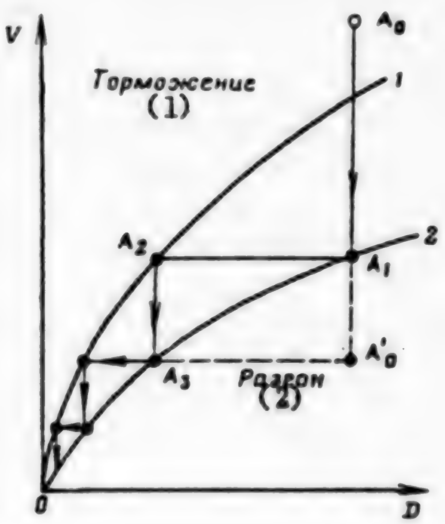
Remote guidance is completed by putting the ship into the effective zone for its autonomous facilities. The dimensions of it are determined by the errors in predicting the motion of the vehicles and in the execution of remote guidance corrections. Where is the ship located at this moment? One is able to talk about this only in terms of probability. For instance; With a probability of 0.9 the ship is situated higher than the station by a distance of 5 km.

To accomplish close-in guidance it is first of all necessary to determine the position of the station relative to the ship, i.e., in the general case to measure six independent characteristics of the station's motion (three coordinates and three velocity components) at some given moment of time. When these characteristics are known, it is possible to figure out the optimum plan for bringing the ship to the station. The plan easily boils down to a two impulse transition. The first impulse directs the ship toward the station and the second equalizes their speed at the moment of approach.

The implementation of this method requires that the ship carry a six-parameter measuring system and a computer to solve the ballistic problem of convergence.

Is it possible to simplify this system? It appears so. From purely geometrical considerations it follows that it is convenient to measure from the ship the distance D to the station, the relative velocity V (velocity on the line of sight), and the angular velocity of the station's movement relative to the ship, i.e., a total of three parameters instead of six.

The program for approach control stored in the on-board computer is diagrammed in the figure. The input quantities for the on-board computer are range D and velocity V as measured from the ship. Each pair of D and V values is coincident with a certain position of the ship (points A) on the diagram. The control problem reduces geometrically to moving point A into the area between the change-over lines, throughout the convergence process. Physically, this means that for every given distance to the station there has to be a definite convergence rate. In other words, the program provides for gradual approach of the ship to the station along the line of sight by application of successive deceleration or acceleration impulses. When considerable distances are involved the convergence proceeds at a fast rate. But when the distance between the ship and the station grows small, the rate likewise slows down. This provides for the slow approach of the ship to the station immediately in advance of docking.



Plan of convergence control on the close-in guidance segment of a flight: 1 and 2 - vehicle changeover lines conforming to the convergence control relationship, $v^2=2aD$, where a is a constant. (1) deceleration; (2) acceleration.

By way of example, we will look at a case of convergence control using the control program shown in the diagram. Assume that the initial radial range and velocity of the station are such that the ship finds itself to be in the deceleration zone (point A_0 in the diagram). The ship is then turned around, the engine is fired for deceleration (to reduce the rate of convergence), and is shut down when the rate corresponding to point A_1 on the change-over line is reached. The magnitude of the deceleration impulse is numerically equal to the line segment between points A_0 and A_1. Between A_1 and A_2 the ship is converging with the station (with engine off). When point A_2 on the change-over line is reached, the engine is again fired for deceleration at an impulse corresponding to the segment A_2 - A_3. Continuing

on, the process is repeated until the origin of coordinates is reached, i.e., until the ship reaches the station. The times for engine firing, corresponding to points A_0 and A_2, are determined by the on-board computer from the results of measurements of the radial range and velocity. In the intervals between these impulses, the angular velocity of the line of sight is measured and is compensated for as needed. For this purpose, the ship is turned around so that the direction of the thrust vector is perpendicular to the line of sight from the ship to the station. The engine is then fired to cancel out the angular velocity.

The convergence of the "Soyuz" and "Progress" vehicles with the "Salyut" station is performed in accordance with just such a program.

5454
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ACADEMICIAN GLUSHKO INTERVIEWED ON LIQUID FUEL ROCKET ENGINES

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 81 pp 36-37

/Interview with Academician Valentin Petrovich Glushko; interviewer not named; date and place not specified/

/Text/ Academician V.P. Glushko, two times Hero of Socialist Labor and Lenin and State Prize laureate, answers questions asked by the editorial staff.

/Question/ Man's entry into space became possible because of progress in rocket and space technology. Right now the development of cosmonautics is being determined by achievements in many sciences, including rocket engine building, to which you have devoted your entire life. What is the fundamental difference between liquid-fueled rocket engines /ZhRD/ and engines of the other known types? What are the difficulties that the designers must overcome along the road to the creation of powerful and economical ZhRD's?

/Answer/ Among all the known engines -- including those used in aviation -- ZhRD's are distinguished by the exceptionally high intensity of the processes taking place in them. In the combustion chamber of a modern rocket engine, the volume of which amounts to several liters, hundreds and even thousands of kilograms of fuel are burned every second. In connection with this, the completeness of combustion is close to unity. The pressure in the combustion chamber frequently reaches 200-300 atmospheres, the stationary temperature of the gasses is 4,400 degrees Kelvin, and the exhaust velocity of the combustion products is 4,500 meters per second. As a result, the thermal flows penetrating the walls of the combustion chamber and the engine nozzle reach huge values. All of this contributes to the appearance of an unstable process in the engine's operation and the appearance of self-excited vibrations over a wide range of frequencies, which in turn is related to significant vibration overloads. It is necessary to search for methods of preventing these phenomena. The functioning of a rocket engine is complicated by the chemical aggressiveness, toxicity, cryogenicity and polyphasal nature of the fuel's components. There is nothing similar in the other known heat-generating units and engines. Moreover, the superlight rocket engine designs that function under these conditions must be highly reliable, for otherwise who would put them in a launch vehicle intended to lift manned spacecraft?

A list of the complicated scientific and technical problems that must be solved when creating ZhRD's would take a lot of time to enumerate. Therefore, I will name only the main ones.

First of all, of course, these are reliability, achieving combustion of a large amount of fuel in a small volume that is as nearly complete as possible, and the stability of the processes taking place in the engine. The latter is necessary for the unconditional elimination of pressure fluctuations in the combustion chamber that are capable of causing an emergency situation. Then we have reliable cooling of the combustion chamber and the nozzle and insuring a uniform and balanced flow of combustion products in the nozzle, which eliminates significant gas-dynamic losses, particularly in the case of a multiphase exhaust.

It is also necessary to solve a number of chemical, metallurgical, technological and other problems.

/Question/ In comparison with modern aviation engines, ZhRD's seem to be simple and understandable. Do you agree with this?

/Answer/ Outwardly this is so. But as the complexity of a machine says nothing about its perfection, so does simplicity not indicate the opposite. In engineering it is most frequently vice versa: the simpler a machine, the more nearly perfect and reliable it is. But this, so to say, is an area of general discussion. I, if you will, would like to talk about the rocket engine. Its seeming simplicity hides some extremely serious and complicated problems. I have already mentioned what they are. I will add that the design of a modern liquid-fueled rocket engine is so complex and laborious that they can be built only with the help of powerful digital and analog computers. Merely for the description of an engine as a controlled member there is a system consisting of hundreds of linear and nonlinear equations.

The processes taking place in liquid-fueled rocket engines have not yet been fully studied. The existing theories do not encompass them in their entirety and do not make it possible to make reliable calculations of an engine's stability in advance, particularly with respect to high-frequency vibrations. Therefore, experimental investigations of the processes occurring in a newly built engine are an integral part of its development and require an extremely serious laboratory and test stand basis.

/Question/ What are the basic ways of improving liquid-fueled rocket engines?

/Answer/ As is well known, many ZhRD's of all possible types were built in different countries in the '40's. However, the principle used as the basis of both our and foreign combustion chamber designs for these engines turned out to be without promise in the sense that it did not open the way to a further substantial increase in engine thrust and, in particular, its specific impulse. And the specific impulse (this is the same as efficiency) is the basic indicator of the perfection and efficiency of an engine.

Thus, the experience the designers had available at the end of the 1940's indicated that any substantial improvement in engine characteristics that were needed for the development of rocket technology would be possible only with an increase in the pressure and temperature of the gases in the combustion chamber. However, this entailed an increase in the heat flow through the chamber's cooled fire wall. In order that it not be destroyed by overheating, it should be made thinner, but calculations showed that then it would not be able to withstand the increased pressure. This was a vicious circle that could be gotten out of only by looking for a fundamentally new combustion chamber design.

And the search met with success. Better engine characteristics were achieved by the use of a combustion chamber design in which a finned fire wall with high-temperature soldering was joined, at the apices of the fins, to a cold outer jacket. As a result, the cooling liquid flowing into the channels between the fins gave the fire wall reliable protection against overheating, while the smallness of the channels' cross-section made the wall able to withstand pressures of many hundreds of atmospheres.

In order to manufacture the fire wall, in the places where the heat was most intense we began to use thin-walled, heat-resistant, high-thermal-conductivity bronze, while in those subject to less heat we used steel, titanium and other metals, and instead of milled fins a corrugated insert was soldered between the walls. The pressure created by the gasses in the chamber was now received by the outer cold, steel jacket.

The new chamber proved to be capable of extended operation at high gas temperatures and pressures, and because of the openwork design it was remarkably light. This gave us the opportunity to use highly efficient fuels in the engines.

In subsequent years the ZhRD's were improved. The designs of such engines as the RD-107 for the first stage of the "Vostok" launch vehicle and the RD-108 for its second stage turned out to be so successful that they are still used to lift manned ships and automatic stations into orbit reliably. And they apparently will remain in service for some years yet.

Launch vehicles with RD-107 and RD-108 engines and modifications of them have insured the successful flights of many artificial Earth, Moon and Sun satellites, have carried automatic stations to the Moon, Venus and Mars, and have powered the manned "Vostok," "Voskhod" and "Soyuz" ships. No less long-lived are the RD-119 and RD-214 engines used in the "Kosmos" launch vehicles.

In order to increase an engine's specific impulse, it was necessary to raise the initial pressure in the combustion chamber even higher. However, this was limited by the losses in the turbopump assembly's drive.

In order that it be clear to readers who are knowledgeable of the fine points of rocket engines, I will say that the turbopump assembly is used to feed the rocket fuel components into the combustion chamber. It consists of pumps and a gas turbine. The turbine is driven by gas taken from the gas generator that is then discharged. This expenditure of gas to operate the turbopump assembly naturally entails some loss of thrust and specific impulse. When the pressure in the combustion chamber of the engines we developed did not exceed 75-90 atmospheres, we could live with the specific impulse losses, which did not exceed 0.7-1.7 percent. However, these losses increased to unacceptable values as soon as the pressure in the chamber was increased several times.

However, a solution was found for this problem. In the new ZhRD design, the gas used in the turbine was returned to the combustion chamber and burned up after being mixed with the incomplete liquid component of the fuel. As a result, we succeeded in reducing the losses to the turbopump assembly's drive to almost zero.

The pressure of several hundred atmospheres that was obtained in the combustion chamber enabled us to build high-thrust engines with substantially reduced dimensions. In particular, this plan was used to build the RD-253 engines for the "Proton" launch vehicle.

These are some of the ways of improving modern ZhRD's. If we speak in general about paths for the further development of any kind of rocket engine, we will be talking about augmenting performance, increasing unit power and using more powerful energy sources.

/Question/ The most variegated propulsion systems have been used in rocket and space technology. What place among them does the ZhRD occupy and will its importance decrease with time?

/Answer/ In spaceships in the emergency rescue system and for soft landings we use powder -- that is, solid-fuel -- engines. Electric engines can be used for orientation and trajectory correction. In comparison with ZhRD's, however, the work they perform can be called auxiliary, since the injection of spacecraft into orbit around the Earth and on flight trajectories to the other planets, as well as maneuvering, is carried out primarily with liquid-fueled rocket engines. In other words, ZhRD's are carrying the main weight of spaceflight.

The birth of nuclear and development of electric rocket engines will not be able to displace ZhRD's from the launching and landing stages of rockets and spacecraft. We cannot manage without them when a high power-to-weight ratio is needed. Besides this, they make it possible to avoid radioactive contamination of an area. Only the discovery of new energy sources that are more powerful than chemical fuels and clean in contrast to nuclear fuels that will result in the creation of engines capable of replacing ZhRD's.

/Question/ In aviation, great importance has always been attached to an engine's specific weight; that is, the ratio of the engine's weight to the thrust it develops. What is the situation with the specific weight of a ZhRD if it is compared with aviation engines?

/Answer/ In rocket technology, the degree of structural perfection of an engine is of more importance than in aviation. For every kilogram of useful load delivered into orbit, right now 25-50 kilograms of launch vehicle starting weight are required. If the design of the launch vehicle's engine is inadequately perfected, a significant portion of its thrust must be expended on its own lifting and acceleration. Therefore, the perfection of the engine determines the weight of the useful load it can carry into orbit, be it a satellite or a spaceship.

As far as aviation is concerned, the most rigorous requirements are for engines being developed for vertical takeoff and landing aircraft. Judging from reports in the foreign press, turbojet lifting engines with a specific weight of 60-70 grams per kilogram of thrust have been built.

In rocket engine building, this indicator is better by an order of magnitude. The specific weight of the powerful ZhRD's developed in the Soviet Union reaches 7-10 grams per kilogram of thrust; that is, the engine's weight is less than the thrust developed by it by a factor of 100-150. The solution of this complex problem

became possible on the basis of the achievement of high working process parameters in the engine, the improvement of its design, and the use of new, light, high-strength materials.

/Question/ What attracted you to cosmonautics?

/Answer/ The study of astronomy, and heavenly bodies as objects of future direct investigation, the compilation of a bibliography, the reading of science fiction. In 1922, Ya. Perel'man's book "Interplanetary Voyages" acquainted me with Tsiolkovskiy, but I could not find many of his publications in the libraries, so I decided to appeal directly to Konstantin Eduardovich with a request that he send me his works. I wrote this letter to Tsiolkovskiy at the end of September 1923. In it I said that for 2 years I had been interested in voyages into space and asked him to help me obtain his books.

At the beginning of October it was with trepidation that I held in my hand a small, handmade envelope with a letter from the Kaluga scientist. In the same month I received two packages of books from Konstantin Eduardovich.

In 1921 the development of a plan for an interplanetary ship -- and its engine, in particular -- and the realization of this project became the goal of my life. Tsiolkovskiy worked on the problems of cosmonautics theoretically. I saw as my goal their translation into life. Konstantin Eduardovich became a great teacher for me.

At first in school and then at the university I accumulated the necessary knowledge and did planning work. However, I was able to begin experimental work only in 1929, in Leningrad, at the Gas Dynamics Laboratory, where on 15 May a subunit for the development of rockets with electric and liquid-fuel engines, which had been organized on my suggestion, began to function. The first three RLA (jet aircraft) liquid-fueld rockets of this series had an ORM-52 engine with 300 kgf of thrust and were intended for vertical flight to an altitude of 2-4 kilometers. The rockets were manufactured in the mechanical shops of the Mint and the Gas Dynamics Laboratory in Petropavlovsk Fortress.

RLA-1 and RLA-2 were uncontrolled rockets, but RLA-3 was controlled. It had an instrument compartment with two gyroscopic instruments. We borrowed them from marine torpedoes. Control over two pairs of rudders in the tail unit was exercised with the help of pneumatic servomotors and mechanical linkages.

Well-developed engines were required for these rockets. We succeeded in getting them only in the fall of 1933. And soon we organized RNII -- the Scientific Research Institute of Jet Propulsion -- where our Group for the Study of Jet Propulsion joined the Gas Dynamics Laboratory. Here, from the very beginning we worked in two areas: the development of rocket engines and the development of rockets. By now each of them has become so complex and specific that we can no longer talk about combining these professions. It is necessary to choose one or the other. I chose the one with which rocket technology begins -- rocket engine building -- because I understood that power engineering is the basis of cosmonautics, and without the successful solution of the problems related to it, spaceflight would remain merely a dream.

11746
CSO: 1866/128

DYNAMICS OF NONLINEAR GYROSCOPIC SYSTEM FOR PRELIMINARY STABILIZATION OF SPACECRAFT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 13 Dec 78) pp 136-139

KARGU, L. I. and YABLONSKAYA, V. A.

[Abstract] The authors analyze the kinematics of a system consisting of a spacecraft and a damping gyroscope, and conclude that its efficiency depends essentially on the damper's damping properties and the friction on the supports of the gyroscope's axis of precession. Figures 3; references 2.
[87-11746]

UDC 621.384.3.017.72:621.59

AUTOMATIC THREE-STAGE HELIUM REFRIGERATING UNIT FOR COOLING RADIATION RECEIVERS OF BST-1M SUBMILLIMETER TELESCOPE ON 'SALYUT-6' MANNED ORBITAL STATION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 18 Jan 80) pp 154-159

SALOMONOVICH, A. Ye., SIDYAKINA, T. M., KHAYKIN, A. S. [deceased], BAKUN, V. N., NIKONOV, A. A., MASLAKOV, V. A., KURKIN, V. N. and KLIMENKO, Ye. N.

[Abstract] The authors present the schematic diagram of the refrigerating unit named above and list its spectifications. They also state that as far as its energy, weight and size are concerned, as well as its simplicity of design, reliability and operating life, it is a promising cryogenic system for long-duration orbital stations. Figures 3; references 13: 10 Russian, 3 Western.
[87-11746]

UDC 62-50

PROBLEMS OF CONTROL FLEXIBILITY AND RELIABILITY IN THEORY OF ON-BOARD TERMINAL SYSTEMS

Moscow AVTOMATIKA I TELEMEKHANIKA in Russian No 2, Feb 81
(manuscript received 29 Sep 80) pp 15-24

PETROV, B. N., ANDRIYENKO, A. Ya., IVANOV, V. P. and PORTNOV-SOKOLOV, Yu. P., Moscow

[Abstract] The authors discuss the principles of construction and control algorithms of on-board terminal control systems for spacecraft, The basic features of these systems are: they are multipurpose and may be multiterminal; they are multimode; they have a long service life. The authors then conduct a theoretical discussion of ways of improving these systems' flexibility and reliability, concluding that the solutions to the problems involved are in a very early stage of development and that in some cases are only beginning to be formulated. References 3: 1 Russian, 2 Western.
[79-11746]

UDC 629.76.015

APPROXIMATE CALCULATION OF QUASISTEADY-STATE GLIDE TRAJECTORIES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 2, Mar-Apr 81
(manuscript received 10 Jan 80) pp 191-199

PARYSHEVA, G. V. and YAROSHEVSKIY, V. A.

[Abstract] Quasisteady-state glide paths are preferred for the descent of a space vehicle to earth, in which the effective lift approximately balances out the projection of the difference between gravity and centrifugal force onto the normal to the trajectory. Such trajectories avoid the skipping of the spacecraft up and down as it re-enters the earth's atmosphere and are realized at entry velocities close to circular in the case of small entry angles and sufficiently large lift to drag ratios. This paper derives approximate analytical formulas for quasisteady-state glide trajectories for the entire descent. The limitations of the approximations are discussed in some detail and more precise equations are written for the low velocity range portion of the path which are suitable for practical applications. The various formulas for the subsonic and supersonic portions of the trajectory are compared graphically with precise numerical calculations. Figures 5; references: 5 Russian.
[121-8225]

REMOTE SENSING STUDIES BY 'SALYUT-6' CREWS

Moscow PRAVDA in Russian 28 Mar 81 p 3

/Article by A. Koval', candidate of technical sciences, department chief, "Priroda" State Center: "A Look at the Earth"/

/Text/ Our planet is large and diversified, but its wealth is not unlimited. Therefore, there has arisen a need for an integrated "inventorying" of the terrestrial globe's natural resources. By its very essence, this problem is an international one.

On the "Salyut-6" orbital station, scientists and specialists from the countries of the socialist community have for a number of years been carrying out an integrated study of the environment on the basis of joint programs featuring the direct participation of cosmonauts who are representatives of those same countries -- members of the CEMA for National Economic Affairs, as advanced in the Integrated Program for Socialist Economic Integration, with due consideration for the requirements of rational utilization of natural resources and protection of the environment.

At the end of 1977, the "Salyut-6" station began to function in the manned mode. USSR pilot-cosmonauts G. Grechko and Yu. Romanenko began to realize the program of Earth observations and photography that was developed at the "Priroda" State Center with due consideration for the interests of different ministries and departments and international collaboration. This work was later continued by all the crews who visited the station.

During the "Salyut-6" flight with the first two international crews, which included cosmonauts V. Remek (CSSR) and M. Hermaszewski (Polish People's Republic), the MKF-6M multizonal camera was used to obtain pictures of the territories of those fraternal nations. May 1978 saw the completion of the development of an integrated program for studying the Earth by international crews from the "Salyut-6" that specified, on the one hand, visual and instrument observations and the photographing with portable cameras of objects and phenomena on the Earth's surface and, on the other hand, photographic surveying with the MKF-6M and KATE-140 fixed cameras. During the course of the flight with the international crew that included cosmonaut S. Jaehn (GDR), the "Biosphere" and "MKF-6M" experiments were performed as part of this program. Here the leading USSR organization was the "Priroda" State Center, while from the GDR it was the GDR Academy of Sciences' Central Institute of Physics of the Earth. After this, analogous joint experiments were prepared by specialists from the USSR and other countries for all international crews.

The first work was done with the Bulgarian-produced "Spektr-15" spectrometer on the flight in which the Bulgarian cosmonaut G. Ivanov participated. This work was continued on later flights. The basic goal of the experiments was to investigate the spectral reflective characteristics of different natural objects and their spatial and temporal variability.

For the first time in the history of spaceflight, joint experiments on the remote sensing of the Earth were conducted by international crews on board the "Salyut-6," leading to the solution of such problems as further improvements in the processes and methods used in space photography, ascertaining the correctness of the transmission by photographic materials of the color of the Earth's underlying surface, working out and improving methods for the visual identification of objects and their state under actual observation conditions, investigating large and strongly disguised geological formations (circular, dome-shaped, craterlike objects and so on) and the water areas of the world ocean.

The cosmonauts have also studied meteorological processes and detected and described polluted areas in the atmosphere and on the land and water surfaces, as well as elemental phenomena. The mapping of forests and agricultural lands is performed regularly from the "Salyut-6," for the purpose of predicting their productivity for the participating nations, determining the characteristics of the hydrographic network and so on.

Specific programs and collation maps, with instructions on the regions to be surveyed and the conditions of the survey, as well as the on-board documentation, were developed for each experiment. In Zvezdnyy, the international crews underwent special training in space natural science, studied techniques for making visual observations and recording the results, and learned how to use portable photographic equipment and the MKF-6M and KATE-140 cameras, as well as the "Spektr-15" spectrometer.

As a result of the performance of international experiments to study the Earth on board the "Salyut-6," the specialists obtained for analytical purposes several thousand space photographs, entries in logs, drawings, cassettes with spectrograms and operational reports from the station over the radio channels.

For instance, the remote sounding of the Earth carried out by USSR pilot-cosmonaut V. Bykovskiy and GDR cosmonaut S. Jaehn (they were assisted by USSR pilot-cosmonauts V. Kovalenok and A. Ivanchenkov) made it possible to obtain important information on faults and circular structures in the southern part of the GDR and the Eastern Albian massif, atmospheric pollution in a number of regions in the GDR, and meteorological phenomena in different parts of the globe, including air currents over flat islands, vortex-type cloud patterns over mountainous islands, atmospheric fronts, thundercloud formations and so forth. USSR and GDR specialists processed photographs taken from the "Salyut-6" in the interests of geology, oceanography, meteorology, glaciology and environmental conservation.

The flight of the Soviet-Hungarian crew consisting of USSR pilot-cosmonaut V. Kubasov and Hungarian People's Republic cosmonaut B. Farkas lasted from 26 May to 3 June 1980. During this time, a diversified program to investigate the environment was carred out (and later continued by USSR pilot-cosmonauts L. Popov and V. Ryumin). At the same time, Soviet specialists participated in synchronous

experiments at test ranges in the Hungarian People's Republic (Abadsalok, Pents, Balaton and Dunay). The subjects of these experiments were aerial surveying and ground measurements with the help of a laboratory airplane and a mobile information and measurement complex that operated under the satellite's track.

During the flight of the crew composed of USSR pilot-cosmonaut V. Gorbatko and Socialist Republic of Viet Nam cosmonaut Pham Tuan, there were 23 observation and photography sessions. Pictures were taken of the territory of Viet Nam, silt deposits in the Mekong River delta, geological structures in Viet Nam and many other features. Forest fire nuclei, powerful cyclones and river flooding were observed. Processing of the multizonal and color photographs will enable the specialists to solve a number of important problems in forest management in Viet Nam and to study structures that are promising from the viewpoint of finding useful minerals.

A great deal of environmental investigation was performed during the flight of the international crew that included the Cuban cosmonaut Arnaldo Tamayo Mendez. These experiments included a study of the structure of the Pinar-del-Rio zone (in the Republic of Cuba), the discovery of salt-dome structures in the central part of the island of Cuba, and an analysis of the color characteristics of the water area's surface.

A new international crew, consisting of USSR pilot-cosmonaut V. Dzhanibekov and Mongolian People's Republic cosmonaut J. Gurragchaa together with V. Kovalenkov and V. Savinykh will study the Earth within the framework of the "Biosphere-Mon" and "Erdem" /translation unknown/ experiments, which include various studies of the territory of the Mongolian People's Republic. These experiments will be accompanied by synchronous aircraft and ground measurements beneath the station's track.

Thus, the assault on space and the use of the results of space research for the good of mankind that was begun 20 years ago by the flight of this planet's first cosmonaut, Yu. Gagarin, are developing successfully. The countries of the socialist collaboration are in the forefront of space accomplishments. The extensive international program for investigating the Earth from on board the long-lived "Salyut-6" orbital station is creating the prerequisites for the further scientific and technical integration of the CEMA member countries.

11746
CSO: 1866/112

'SALYUT-6': PROBLEMS IN INCREASING EFFECTIVENESS OF OBSERVATIONS

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 81 pp 42-43

/Article by Colonel V. Kovalenok, hero of the Soviet Union, USSR pilot-cosmonaut, and A. Koval' and A. Tishchenko, candidates of technical sciences: title as above/

/Text/ Visual and instrument observations made from the "Salyut-6" orbital station demonstrated the great possibilities of this method for solving important problems for the good of the national economy and science. The 185-day flight of L. Popov and V. Ryumin indicates the visual investigations are particularly effective for the solution of search problems when the areas of interesting natural formations and their time of appearance are not known beforehand.

Investigations of the fine structures of objects require a highly sensitive analyzer, a large field of view for adequate spatial resolution, and repeatability of the observations. The last factor is very important: it really is necessary to make sure of the actuality of the existence of formations or phenomena. For instance, the second main expedition of V. Kovalenko and A. Ivanchenkov on the instructions of specialists from the Aerogeologiya Scientific Production Association searched for ring structures in the Ukraine and Moldavia. Their existence was predicted by geology. However, this matter was made more complicated by agricultural features in that region. Therefore, the interpretation of the vast number of photographs made with various space equipment did not yield the desired results.

From 15 June to 2 November 1978, the cosmonauts conducted systematic visual observations of the region in question. As a result, several ring structures were entered on the map. They were discovered on the basis of the following features that manifest themselves only when seen from space. The crew noticed seasonal variability in the color contrasts of plant growth and a characteristic distribution of morning fog formations. Observations made with different levels of illumination contributed to this success.

As is known, the crews of the "Salyut-6" solved a whole complex of problems related not only to station control and maintenance of its on-board systems and equipment, but also to the fulfillment of assignments for special purposes, among which the observation of the environment occupied an important place. Since this was something new to the cosmonauts, they required advance training in a special course in space natural science and had to acquire the skills needed to make observations by using flying laboratories.

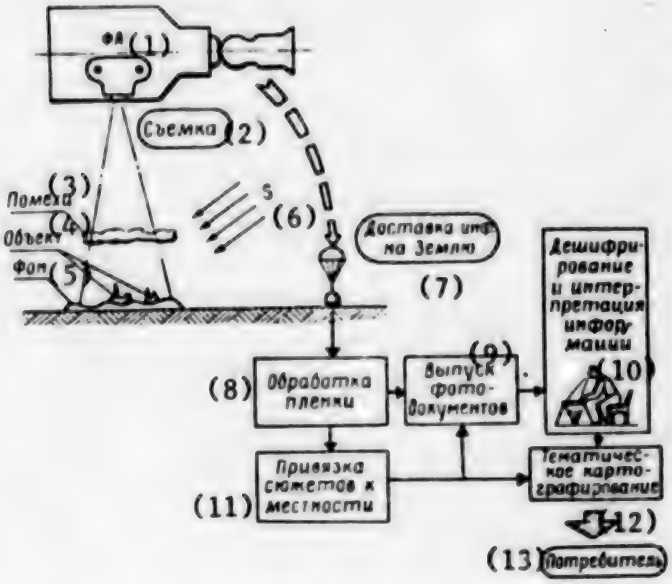

Figure 1. Diagram showing collection and utilization of space information on natural resources, with processing on Earth.

Key:
1. Photographic equipment
2. Survey
3. Interference
4. Object
5. Background
6. Sunlight
7. Delivery of information to Earth
8. Film processing
9. Photographic document production
10. Deciphering and interpretation of information
11. Correlation of subject with locality
12. Thematic mapping
13. Consumer

The main purpose of visual and instrument investigations is to create a "data bank"; that is, to amass information on the features characterizing different natural formations and processes on our planet. In the future this "data bank" can be used in the development of permanently operating automatic systems for investigating the Earth and its natural resources from space. It goes without saying that lengthy work on the part of crews on board orbital stations makes it possible to speed up the information collection process and increase the effectiveness of the solution of a whole series of problems in space natural science. This is achieved by selectivity and a reduction in the amount of information recorded, along with preliminary processing of it before transmission to Earth. Cosmonauts can observe and record unique and infrequently recurring processes. Besides this, by controlling fixed photographic equipment and simultaneously monitoring the surveying conditions (cloudiness, haze, illumination, the state of the atmosphere and the portholes), they can achieve the best quality photographs.

In order to make a better evaluation of the capabilities of a cosmonaut-operator for observing the environment, let us follow a complete information transmission cycle. From Figure 1 it is obvious that with automatic space equipment it is necessary to accumulate surplus information, from which the useful data are extracted on Earth. In connection with this, it is necessary to analyze photographs and prints in different wavelength bands, with all the interference and distortions, for contrast and color as well as for spectral differences.

The situation is somewhat different when there are cosmonauts on board (Figure 2). Of course, in order to analyze information the crew must have the skills needed not only for the correct perception of the specific features of objects, but also for their interpretation. Let us mention here that the dynamic features of a process are the most critical and -- sometimes -- informative ones of a process that is being observed. Cosmonauts have the capability of using a photograph or print that has been developed on board to plot additional information that appears when the observation conditions (illumination, seasonality) change.

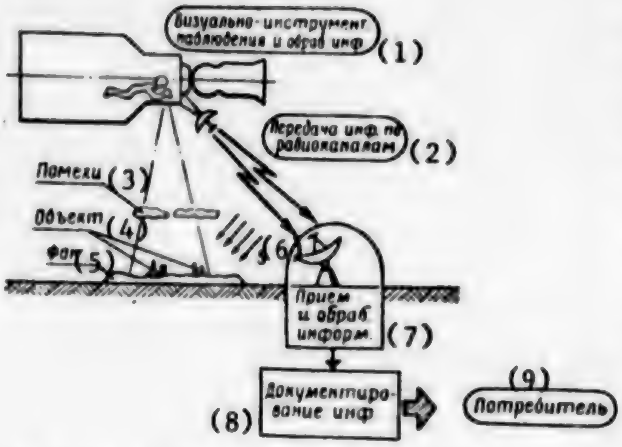

Figure 2. Diagram showing collection and utilization of space information on natural sources, with operational processing on board a manned orbital station.

Key:

1. Visual and instrument observations and information processing
2. Information transmission by radio
3. Interference
4. Object
5. Background
6. Sunlight
7. Information reception and processing
8. Information documentation
9. Consumer

What can contribute to the improvement of the quality and efficiency of investigations of the Earth's natural resources using the visual and instrument observation method? First of all, the presence of a sufficient number of portholes. Experience gained during flights also indicates the necessity of increasing the observation time for a single object. The manned orbital station must have supplementary equipment for observation purposes: photographic equipment, binoculars, viewfinders, dictaphones, tape recorders, and facilities for primary photochemical developing. Finally, the amount of special training the crew receives in space natural science plays a role of no little importance.

For instance, the crew commander on the 185-day expedition in the "Salyut-6"-"Soyuz" complex, L. Popov, thinks that he could have begun visual observations as early as the first days of the flight. In the opinion of the cosmonauts, their special training, the work experience of previous expeditions, and the special features of the crew makeup all played a role in this work. During a previous 175-day flight in the orbital complex, Flight Engineer V. Ryumin made observations for the benefit of space natural science. He began to share his experience with the crew commander immediately.

L. Popov made a series of training flights in a flying laboratory belonging to the TsPK imeni Yu.A. Gagarin. In addition to specialists and scientists, cosmonauts from preceding expeditions in the orbital complex participated in the training of the crew to make visual observations. Popov thinks this training method is quite effective and that it should continue to be used.

The visual and instrument method takes on particular urgency during the investigation of processes and phenomena that occur in the environment very rapidly. Evaluating the situation, a cosmonaut can record the birthplace of tropical cyclones and typhoons, underwater volcanism, the movements of active glaciers, the ice situation in the world ocean, the formation of different levels of its aqueous surface, the amplitude of the fluctuations in ocean currents and the location and migration of plankton fields, in addition to determining large-scale circulation in the world ocean. In all these cases, the information would undoubtedly be transmitted directly to the consumers of the results of the observation process.

The 20 years of manned spaceflight experience has demonstrated convincingly the possibilities of cosmonauts as visual analyzers for observing the Earth and natural

Comparative Characteristics of Different Observation Systems

No	Characteristic	System		
		Eye	Photographic Equipment	Television
1	Spectral resolution, in nanometers	2-4	40 + 100 (infrared)	100-150
2	Minimum amount of contrast (in percentages) at which terrestrial details are differentiated from space	4	30	50
3	Minimum amount of solar illumination of observed object, in kiloluxes	10^{-2}-1	10-15	30-40
4	Minimally necessary angle of Sun elevation above the horizon, in degrees	0-5	10-15	20-35
5	Dynamic characteristics of system in registering objects:			
	object registration (perception) time, in seconds;	0.02-0.2	0.5-1	0.1-0.2
	angular velocity of system rotation, in degrees per second	300	1-2	1-2

formations and for collecting data for the benefit of science and the national economy. The human eye is an unusually sensitive radiation receiver. Here it is appropriate to mention the eye's capability to see the necessary objects from an orbit in space. Human vision is distinguished by a high threshold sensitivity in the visual band of the spectrum and a broad dynamic range, which enables a cosmonaut to work under conditions of huge changes in brightness and illumination. High contrast sensitivity and color differentiation are characteristics of the eye. Its resolving power reaches a single angular minute. It is especially important that all of these exceptional positive properties are combined in a single visual system. The data in the table above make it possible to compare the eye's characteristics with those of several optical observation systems.

Let us examine, for example, how a cosmonaut realizes his vision's ability to work under conditions of reduced background brightness; that is, when the Sun is low over the horizon. From the table we see that the minimum angle of the Sun over the horizon is 10-15° for photographic systems, while for the eye it is less than 5°. This means that the visual observation time for terrestrial objects is increased by more than 30 percent.

The area of application of visual and instrument observations is quite broad. It includes oceanography, agriculture and forestry, geology, meteorology and conservation of the environment. During the realization of the 185-day program of scientific and technical research and experiments by USSR Pilot-Cosmonauts L. Popov and V. Ryumin, in the Flight Control Center it was possible to see representatives of various departments and scientific establishments. Specialists engaged in investigating natural resources and the environment communicated with the cosmonauts on a regular basis. This indicates that the visual and instrument method is coming more and more to the fore in the service of science on the Earth. Each new flight sees an increase in the performance of research on the orbital station.

Providing that the "Salyut" vehicles are equipped with specialized equipment and that the crews have the appropriate training, the visual and instrument method will

make it possible to achieve a considerable improvement in the effectiveness of orbital scientific research complexes for the solution of scientific and national economic problems.

11,746
CSO: 1866/82

VISUAL OBSERVATION OF THE OCEAN FROM SPACE

Moscow KRASNAYA ZVEZDA in Russian 3 Apr 81 p 4

/Article by Engr-Col M. Rebrov, special correspondent: "The Ocean Planet"/

/Text/ Service information was being passed and the "Photons'" working day was drawing to a close when Vladimir Kovalenko's enthusiastic voice suddenly rang out: "The ocean has opened up!"

In this case this meant that the cloud cover that, unfortunately, quite frequently hides the Earth from inquisitive eyes in orbit had melted away. However, this "opened" also had an entirely different meaning.

I remember, from some years ago, a dialog the Flight Control Center had (and continues to have) with some cosmonauts. It began like this:

"This steel-gray uniformity is fatiguing sometimes. The unnatural metallic gleam makes it impossible to examine anything."

"Dawn" (the Center's call sign) was puzzled: "Is everything really solid gray?"

"No, the colors change. Everything depends on where the Sun is and how it shines."

"Dawn": "Get used to it and look for an angle of approach."

"The Sea of Okhotsk is brownish green and the Caspian is a deep, dark blue...On our preceding pass we saw unusually colored spots in the ocean."

Time and experience in making observations from orbit have changed our concept of the ocean.

"Dawn": "And how does the ocean look now?"

"Multicolored, iridescent, patterned, as if it were alive...We saw the track of a ship. Guadeloupe Island seemed to be swimming in the ocean..."

In the break between communication sessions I talk with Candidate of Technical Sciences Lev Aleksandrovich Ronzhin, the representative of the "Priroda" State Center, which is concerned with the problems involved in studying the Earth from space.

"Every new flight, every trip by man into near-Earth orbit opens new possibilities for investigating nature," says my collocutor, who then adds, " Actually, we have already seen the formation of a new branch of space science: space oceanography."

Our planet (Gagarin called it "sky blue") has completed 20 revolutions around the Sun since the first manned flight in April 1961. During this time cosmonautics, which from the beginning we all perceived to be more of tomorrow than of today, has had its revenge: it has astonished everyone with new achievements and has broken into ever newer areas of knowledge, bringing with it the solutions of the most complex and sometimes intricate problems, new ideas and unexpected discoveries, without even mentioning the technical possibilities in many spheres of human activity.

Do you remember Gagarin's words? "Space is a place where the efforts and talents of people in the most variegated terrestrial specialties can be applied." Today, oceanographers, also, dream of having a permanent work place in orbit. It is not just curiosity that is attracting them into space. The role of the world ocean in the life of the people on this planet is expanding rapidly. We must evaluate its biological and energy resources, understand the mechanism of its effect on weather and climate, define more precisely the most advantageous routes for ocean shipping, and protect the oceans and seas from pollution. They cover a large part of our planet (about 71 percent), while the continents are essentially islands surrounded by water.

The usual means of oceanographic research -- studying currents, thermal irregularities and places where bioplankton (and, consequently, fish of commercial value) accumulate, monitoring the purity of the surface, solving navigation problems, compiling accurate charts, determining tidal zones and the energy of the tides, registering the birthplaces of typhoons and so on -- are not very efficient. Science needs data on a global scale that have been collected in a short period of time. In order to approach the future in the matter of mastering the oceans and seas, observations and investigations are being made from space.

What do we know about the ocean?

We can again recall Yuriy Gagarin's first impression about the "ocean planet," we can cite the gigantic figure that characterizes the amount of water on the surface of the terrestrial sphere: 1.5 billion cubic kilometers! We can, with regret, say that the main part of oceanographic research has been conducted on only 40 percent of its water area. However, all of this will not answer the question.

If we talk not about the past, but about the future of terrestrial civilization, we most likely will soon have to go begging to Neptune, the god of the seas, and ask him to share his riches with mankind.

And his wealth is vast. The amount of dissolved mineral salts reaches an astronomical figure: $48 \cdot 10^{15}$ tons. At one time Academician L. Zenkevich calculated that if we were to extract all the salt from the water, it would be possible to cover the entire Earth with a layer of it 45 meters thick. If it were heaped up only on the land, the height of the covering would grow to 153 meters.

The food resources in Neptune's kingdom are also colossal. Its biomass -- the mass of everything that lives and grows in the ocean -- is 20-30 billion tons (not counting plankton).

It is correct to call the world ocean the "lungs" of Earth. About half of the oxygen in our planet's atmosphere is produced during photosynthesis by phytoplankton inhabiting the ocean.

Here is another calculation. Modern science has proven that for replenishing food resources, one hectare in the sea is more promising than the same area on dry land. Maybe the world ocean could become a huge food combine. Maybe, but...

A look from orbit reveals the criminal traces of human activity in the ocean. In the last 10 years alone, there have been more than 50 accidents involving large tankers in different regions of the "ocean planet." A "black tide" -- 230,000 tons of oil -- reached shore from the American vessel "Amoco Cadiz," and a Liberian tanker spilled more than 300,000 tons into the sea near the island of Tobago. Just as much oil was discharged into the ocean where there was an accident involving exploratory wells near the coast of Mexico.

A lot of petroleum products fall into the sea when tankers are flushed out and ballast water is dumped. In 1972 alone, 2.25 million tons -- almost 10 times more than in the "Amoco Cadiz" catastrophe -- were poured into the sea. It takes 7-10 years for the natural biological balance to be restored after such a catastrophe.

The biological consequences of pollution of the seas and oceans cannot help but cause concern. According to estimates made by the United Nations, the world ocean's annual productivity has been reduced by more than 20 million tons of biomass in comparison with what it was before the onset of intensive pollution.

Today the "ocean planet" is being studied from orbit. Space oceanography has been called on not only to add to our knowledge about little-studied areas of the ocean, but also to monitor its status. In other words, we need operational and quite complete measurements of the appropriate characteristics throughout the entire water area of the world ocean as a whole.

Visual observations must be supplemented with so-called remote instrument sounding. Scientists think that the registration and analysis of the sea surface's electromagnetic radiation and the infrared "portrait" of different sections of the ocean, along with spectrographic studies of "fish slicks" (surface-active films appearing in places where schools of fish congregate) and other characteristics will make it possible to produce temperature maps of the ocean's surface. They will help in determining the direction and intensity of currents, distinguishing thermal anomalies, tracing the formation and development of oceanic vortices, understanding the "weather kitchen" in the ocean's depths, and investigating the nature of many as yet mysterious processes.

Scientists dream of creating a chemical model of the ocean and a geological model of the Earth's crust that is hidden under the ocean layer and of understanding the "nature" of the elements so that their violent appearances can be predicted on a timely basis and with sufficient accuracy.

I have saved the record of yet another curious dialog between "Dawn" and "Photons."

"We see ledges...From here it's difficult to determine, but sometimes they are as much as 10 meters."

"Ledges in the water?" asked a surprised Earth,

"Yes. The water's surface is rough. Sometimes we see somewhat smaller ledges. Little steps, little steps..."

"This is very interesting. Keep making observations."

"We will."

Vladimir Kovalenok was the first Earthman to detect abrupt "ledges" and "uplifts" in different regions of the water area. He saw a "trough" near the Caroline Islands and a "swell" up to 100 kilometers long in the Timor Sea.

"The ocean has so many secrets and mysteries," says L.A. Ronzhin, "that it will take many generations of people to unravel them. I find it amazing that it is in the sea -- the boundless and endless receptable of life -- there could be lost one of the most interesting engimas of the living world. You see, 'we' came out of the sea onto the land..."

Yes, there are many mysteries, and problems, too. Today we are solving the main ones: weather prediction, commerical fishing, insuring the safety of ocean navigation, and preservation of the environment.

During a routine communication session with the "Salyut-6," the following report was received in the Flight Control Center:

"The ocean is open. We are continuing our observations."

11746
CSO: 1866/103

DEVELOPMENT OF SPACE METHODS FOR OCEAN STUDY

Moscow IZVESTIYA in Russian 29 Jul 81 p 3

[Article by B. Konovalov, special IZVESTIYA correspondent: "Ocean Patrol"]

[Text] Our native planet far more warrants the name "Ocean" than the name "Earth." Two-thirds of the surface of our earth is occupied by water areas. Life on the earth itself was generated in the ocean. For countless centuries it served man both as a source of food and as a convenient transportation route. In the second half of the 20th century the role of the world ocean increased enormously. Suffice it to mention that now approximately 15% of the proteins of animal origin consumed as human food is provided by sea fisheries. About 20-25% of the world production of petroleum and gas already comes from the shelf zone. The first sea mines for the production of other minerals are appearing. There is now a clear understanding that without a good knowledge of the processes transpiring in the world ocean it is impossible to solve the problem of long-range weather forecasting. Accordingly, throughout the world there has been a marked increase in attention to investigations of the ocean and they have acquired a large-scale character.

Virtually during just the time of the creative life of one generation of scientists the study of the ocean has progressed from individual, poorly outfitted investigations, carried out by a few enthusiasts, to an industrial level of experiments implemented through the efforts of specialists of several countries, in some cases on a global scale. This can be seen especially clearly when one becomes acquainted with the work of one of the leading oceanographic institutes of the Soviet Union—the Marine Hydrophysical Institute, Ukrainian Academy of Sciences (MHI).

In 1929 the famed Soviet scientist Academician V. Shuleykin established the Marine Hydrophysical Laboratory in the Crimea, at Katsiveli. There, in essence, the foundation was laid in our country for a new science—marine physics. The equipment was simple indeed. A small cannon, shooting small spheres into the sea, and a spyglass, by means of which the scientist determined current velocity, observing how these small spheres floated "at the will of the waves," are still kept at Katsiveli as historical mementos. "Shuleykin's rock," a granite rock connected to the shore by a trestle, from which sea temperature and the nature

of the waves were studied, has also become a historical landmark. The height of waves was determined from the wetting of an ordinary board with graduations. The laboratory staff was small--only a few scientific specialists.

Now the Marine Hydrophysical Institute, whose nucleus was the former Shuleykin laboratory, has a staff of over 2,000 persons. They have at their disposal seven scientific research ships, including two extremely large vessels, the "Mikhail Lomonosov" and the "Akademik Vernadskiy," two aircraft laboratories and several modern electronic computers. An artifical "rock," a scientific research platform constructed on a pile base directly in the open sea, has made its appearance at Katsiveli not far from "Shuleykin's rock." In its laboratories researchers can carry out observations with a great array of instruments, with any duration.

And the very division of the Marine Hydrophysical Institute at Katsiveli, and indeed, the entire Black Sea, has become a control-calibration polygon for satellite investigations of the ocean, in whose development the Marine Hydrophysical Institute is now the leading organization. When Boris Alekseyevich Nelepo became director of the institute in 1974 he felt that effective investigation of the ocean was impossible without employing space vehicles and satellite techniques gradually advanced to the forefront of investigations.

The launching of the "Cosmos-1076" satellite on 12 February 1979 marked the beginning of the "space era" for the institute. Studies for investigation of the planet, already initiated in the USSR by the "Kosmicheskaya Strela," "Meteor" and "Cosmos-243" satellites, now received new development and an oceanic flavor. For the Sevastopol' specialists this was a "reconnaissance in force." As the satellite designers chided the scientists, the institute then underwent a "training course for the young soldier." First of all, they understood that it was naive to assume that the launching of a satellite could immediately solve all problems. The satellite, rising to cosmic altitudes, broadened their horizon both literally and figuratively. Indeed, enormous expanses of the ocean became accessible for observations over great areas at the same time, not in individual tiny regions, as was the case when working with sea ships. But what an enormous flow of information was received! During the time of operation of the first oceanological satellite the institute received hundreds of times more information than during the long years of work of all expeditionary sea ships. Only high-capacity, specially "taught" electronic computers could cope with the enormous flow of information.

For the fully adequate processing of these data it was necessary to create a data bank so that the electronic computer would know the mean annual characteristics of different regions of the world ocean and would comprehend that such-and-such a curve corresponds, for example, to shallow waters, whereas another corresponds to deep regions. It was necessary to clarify how the registry of ocean characteristics is influenced by illumination conditions, the wind and state of the atmosphere. In short, it was necessary to analyze thoroughly what the satellite instruments had registered. This task was not simple and it is even now being solved by the specialists at the Marine Hydrophysical Institute in collaboration with specialists of the scientific teams of the USSR Academy of Sciences headed by Academicians V. Kotel'nikov, A. Obukhov and R. Sagdeyev.

The second oceanological satellite, the "Cosmos-1151," was launched on 23 January 1980. It had the same missions as the first. It has the same quasi-polar orbit with a mean altitude of 650 kilometers. Only one thing had changed: the institute now had experience behind it. The satellite is still functioning properly and for more than 1 1/2 years will provide extremely valuable information and is forming a world ocean data bank. To be sure, this is first and foremost an enormous tribute to the creators of the satellite itself.

In collaboration with the body of scientists headed by Professor N. Armand of the Institute of Radioengineering and Electronics, USSR Academy of Sciences, the specialists of the Marine Hydrophysical Institute have been able to detect zones of intensive storms and determine the characteristics of ice fields. On the basis of the classical investigations already carried out under the direction of Academician A. Obukhov using data from the "Cosmos-243" satellite, it was possible to perfect methods for the quite precise determination of the atmospheric moisture content and the liquid-water content of clouds. A method was perfected for constructing maps showing the temperature of the ocean surface with errors not exceeding two degrees. Such maps are important for both the fishing fleet and for the meteorological service, especially for making long-range forecasts. According to the new concepts formulated and validated by Academician G. Marchuk and his students, the heat stored in the equatorial regions of the ocean determines the effect of powerful currents, such as the Gulf Stream, on the formation of weather and climate in the European USSR. For example, on the basis of satellite data scientists "reconstructed" the factors responsible for the cold spring and summer of last year. In February 1980, in the zone of generation of the Gulf Stream, the ocean temperature was lower by 1.5-2 degrees than the mean annual norm. After 1 1/2-2 months the satellite detected this anomaly, already to the east of Newfoundland. Then the cooling reached European waters, and as a result, cold and rain descended on our country. The "echoes" of what occurs in the tropics, after a season or even a half-year, are still heard over our territory.

Now there is a need for a mass of statistics and scrupulous checking of theoretical models in order to create a basis for long-range forecasts of weather and climate. And it is exceedingly important for agriculture to know whether the summer in some particular region will be rainy, cold or arid. Long-range forecasting is vitally important for all countries and therefore work in this direction has been included in the "Intercosmos" program.

The "Intercosmos-21" satellite was launched on 6 February 1981. It was intended for oceanic research. Now, for the first time in history, an experimental space system of two oceanological satellites is operating over the planet: the Soviet "Cosmos-1151" and the international satellite "Intercosmos-21." At one time the "Meteor" meteorological system also began with two satellites. Now a space service for observing the ocean is making its beginning. The oceanological satellites now operating, on the one hand, supplement one another with respect to the instrumentation carried on board, and on the other hand, make it possible at the intersections of orbits to make observations of one and the same regions from different altitudes and to compare the collected data.

Yu. Terekhin, head of the section on remote sensing methods, states: "Indeed, for this experimental system of satellites the entire Black Sea is a control-calibration polygon. The Crimean Space Communication Center receives satellite information which is sent for processing to Sevastopol' at the Marine Hydrophysical Institute. The divisions at Katsiveli and in Tendra and sea ships transmit real data for comparison with satellite data and data from aircraft laboratories operating at different altitudes and this makes it possible to evaluate the influence of the atmosphere on orbital information."

Such observations are being made in different regions of the earth at the surface of the seas and oceans. The "Akademik Vernadskiy" has made voyages to the Indian Ocean and the "Mikhail Lomonosov" has made voyages in the Mediterranean Sea and in the Atlantic. The "Mikhail Lomonosov" carries scientists from the German Democratic Republic and Hungary and also a multichannel spectrometer, a precise copy of that which is carried aboard the "Intercosmos-21" satellite.

"We are planning to explore two characteristic regions," said V. Urdenko, deputy head of the expedition prior to his departure on a voyage of the "Mikhail Lomonosov." "One is poor in life, in the Mediterranean Sea, whereas the second is in the Atlantic in one of the biologically productive shallow-water areas. These regions differ substantially optically. The sea deserts are of a blue-violet color. With respect to transparency they are the same as distilled water, whereas biologically productive waters are turbid and have a greenish hue. The final objective of our investigations is the detection of biologically productive regions of the world ocean from orbit."

The well-known Russian proverb "fish are found where it is deeper" is not always true for the seas and oceans. There, on the contrary, fish frequently seek shallow waters where the water is well illuminated and heated and where there is food. The introduction of the 200-mile economic zone by the coastal countries has removed from the free zone of fishing the most productive part of the waters of the world ocean. The fishing fleet has been forced to move into the open ocean, whose unbounded expanses for themost part constitute sea deserts. Cosmonautics is now helping to detect oases of fish life in these areas.

At first the cosmonauts did not believe that they were seeing underwater ranges, such as the Mid-Atlantic Ridge. After all, light penetrates into water for only several tens of meters, whereas the peaks of an oceanic ridge are at kilometer depths. It became clear with time that the zone of mixing of warm surface and cold deep waters seemingly duplicates the underwater relief. A "liquid floor" is formed beneath this zone of mixing, consisting of denser waters. Their vertical oscillations, sometimes exceeding a hundred meters, are called internal waves. They change not only the physical and biological characteristics of the upper layers, but also the roughness of the ocean surface. And literally on the screen of the television set (for the time being extremely imperfectly) the cosmonauts see the underwater relief features. These phenomena are also of extremely great importance for investigations of life in the ocean. The regions over the rises of the ocean floor seemingly simulate shallow waters and are biologically productive.

The eddy formations discovered in the investigations of Soviet scientists under the direction of Academician L. Brekhovskikh were also extremely important. Soviet cosmonauts, and especially G. Grechko and V. Kovalenok, effectively studied them from space. So-called cyclonic eddies, which sometimes have a diameter of several hundred kilometers, exist for years and serve as singular gigantic pumps drawing from the depths waters which are well enriched with mineral salts. Phytoplankton begins to develop under these favorable conditions, and then the next links in the living chain, which constitute the food for fish, and they come to these sea pastures. "We, in essence, are taking only the first practical steps in creating a space service for observing the ocean. Soon the range of electromagnetic waves used in observations will be broadened," says Academician B. Nelepo, Ukrainian Academy of Sciences. "It is now becoming clear that because of satellites we can know not only the surface pattern of phenomena in the ocean, but also the volumetric, deep picture. Internal waves occur very extensively in the ocean. Their manifestations at the surface can be registered from aboard satellites and it is possible to judge what is occurring in the upper layer of several hundred meters which is most important for us. In particular, it is possible to estimate the heat reserve in the waters of different regions, as is extremely important for both long-range weather forecasting and for the fishing fleet."

The mastery of an ocean which was new for man, space, was also useful for expanding knowledge of the most ancient and the most familiar ocean. Now the study of the terrestrial and space oceans is advancing step by step. The ocean patrol from orbit will serve man.

5303
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UDC 522.61

EFFECT OF MULTIPLE SCATTERING ON POINT'S DIFFUSION FUNCTION AND FREQUENCY-CONTRAST CHARACTERISTICS OF AEROSOL ATMOSPHERE IN SPACE METEOROLOGY PHOTOGRAPHIC SURVEYING PROBLEMS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 1, Jan-Feb 81 (manuscript received 7 Dec 78) pp 139-143

BELOV, V. V. and KREKOV, G. M.

[Abstract] The authors attempt to determine a point's diffusion function and the frequency-contrast characteristics of a model aerosol atmosphere, with due consideration for the multiple scattering of optical radiation, and to compare the results with the corresponding characteristics found by a single scattering approximation. In order to do this, the authors had to develop a numerical modeling algorithm for evaluating the point diffusion function and an algorithm for calculating the frequency-contrast characteristics and select a valid optical model of the aerosol atmosphere and the characteristics of the photographic system that makes it possible to analyze the extent of the effect of multiple scattering on the characteristics of the image of contrasting objects on the underlying surface. Their conclusions are: the results obtained with single scattering theory cannot result in satisfactory quantitative estimates of the frequency-contrast characteristics of the entire thickness of the atmosphere because of the significant level of multiple radiation scattering; the substantial dependence of the functionals of the full transfer equation's solution on the geometry and optical parameters of the atmosphere makes it mandatory to assume a critical attitude toward simplified model conditions that ignore these relationships. Figures 6; references 7: 5 Russian, 2 Western.
[87-11746]

UDC 550.814:528.94

ANALYSIS OF INFORMATION CONTENT OF GEOLOGICAL MAPS AND SPACE PHOTOGRAPHS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOLOGICHESKAYA in Russian No 5, May 81 (manuscript received 5 Jun 80) pp 114-123

POROSHIN, S. V., State Scientific Research and Production Center "Nature"

[Abstract] In his analysis, the author uses both original-scale and enlarged space photographs taken from the "Salyut-4" orbital station, which are differentiated from aerial photographs by severe distortion of the spectral characteristics of objects on the Earth's surface. The advantage of this distortion is that it results in better decipherability of geological structures. After discussing several examples of the use of space photographs in geological studies, the author concludes that one of their best uses will be in structural-metallongenic analysis. Figures 3; references 14.
[123-11746]

USSR PROPOSES NEW TREATY BANNING WEAPONS IN SPACE

Gromyko Letter to UN

Moscow IZVESTIYA in Russian 12 Aug 81 p 4

[Letter of A. Gromyko, USSR minister of foreign affairs: "Do Not Allow the Militarization of Space"]

[Text] Dear Mr. Secretary General,

The Soviet Union proposes for inclusion in the agenda of the 36th Session of the UN General Assembly the matter of "Concluding a Treaty to Ban the Stationing of Weapons of Any Kind in Outer Space."

In 1982 we will observe the 25th anniversary of the day marking the beginning of man's conquest of space--one of the greatest achievements of 20th century science and technology. Even today the use of outer space is bringing great benefits to mankind in such spheres as communications, the study of the earth's natural resources, meteorology, navigation, and many others. It can be said that people are beginning to make space "habitable."

As long ago as 1958, at the very start of the space era, the Soviet Union introduced a proposal in the United Nations providing for a ban on the use of outer space for military purposes. Over the entire course of succeeding years, the Soviet Union has been constantly advocating--and today advocates--the proposition that space be an area devoted exclusively to peaceful cooperation. It can be noted with some satisfaction that a great deal has been accomplished in this direction.

In 1963 an international agreement was concluded--the Treaty on Banning Nuclear Weapons Testing in the Atmosphere, in Outer Space and Under Water. The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies provides for using the moon and other celestial bodies for exclusively peaceful purposes, and also prohibits any other method of placing in earth orbit, or stationing in space, any objects with nuclear weapons or any other varieties of weapons of mass destruction. The 1979 agreement on the activities of states on the moon and other celestial bodies has been developing and solidifying national obligations with regard to the exclusively peaceful use of the moon and other celestial bodies in our solar system.

However, all of the enumerated international documents fail to exclude the stationing in space of certain varieties of weapons which do not fall under the definition of weapons of mass destruction. As a result, the danger of the militarization of outer space has been preserved, and, of late, has been growing.

The Soviet Union believes that this must not be tolerated. It advocates keeping outer space forever clean and free of any kind of weaponry, and preventing space from becoming a new arena for the arms race and a source of aggravation in relationships between states. The Soviet Union is of the opinion that concluding an international Treaty on Banning the Stationing of Weapons of Any Variety in Outer Space would serve to achieve these aims.

A draft of our proposed treaty has been attached to this letter.

I ask, Mr. Secretary General, that you consider this letter an explanatory note as envisaged by the procedural rules of the General Assembly, and that you disseminate it along with the draft text of the treaty as an official document of the UN General Assembly.

A. Gromyko, USSR Minister of Foreign Affairs.

Draft Text of Treaty

Moscow IZVESTIYA in Russian 12 Aug 81 p 4

[Text] The states parties to this treaty,

guided by the aims of consolidating peace and international security,

proceeding from their obligations according to the Charter of the United Nations to refrain from threat of force or the use of force in any way not consistent with the goals of the UN,

striving to prevent the conversion of outer space into an arena for the arms race and a source of exacerbation of relations between states,

have agreed as follows:

Article 1

1. The states parties to this treaty obligate themselves not to place objects with weapons of any kind into earth orbit, not to put such weapons on celestial bodies and not to position such weapons in outer space in any other form, including reusable manned space vehicles of the type which exist today as well as other types which the states parties to this treaty might acquire in the future.

2. Each state party to this treaty obligates itself not to aid, encourage or induce any state, group of states or international organization to engage in activity contradictory to the provisions of paragraph 1 of this article.

Article II

The states parties to the treaty will utilize space objects in strict conformity with international law, including the UN Charter, in the interests of maintaining international peace and security, and of developing international cooperation and mutual understanding.

Article III

Each state party to the treaty obligates itself not to destroy, damage or disturb the normal functioning, and not to change the trajectory of flight of space objects of the other state party, if such objects have, in turn, been injected into orbit in strict conformance with paragraph 1 of Article I to this treaty.

Article IV

1. In order to provide confidence in observation of the provisions of this treaty, each state party will utilize the national technical means of verification at its disposal in such a way so as to conform with the universally recognized principles of international law.

2. Each state party obligates itself not to interfere with the national technical means of verification of other state parties which are carrying out functions in conformity with paragraph 1 of this article.

3. To facilitate realization of the goals and provisions of this treaty, the state parties will, in the event of necessity, conduct consultations with one another, present inquiries and furnish information with respect to such inquiries.

Article V

1. Any state party to this treaty may propose amendments to the treaty. The text of each proposed amendment must be presented to a depository, who will circulate it immediately among all the states parties.

2. The amendment enters into force for each state party to this treaty that has adopted the amendment, after the documents on its adoption by a majority of the states parties have been transmitted to the depositary. The amendment will enter into force from that time forth for each remaining party on the day that party transmits its adoption document to the depositary.

Article VI

This treaty will remain in effect indefinitely.

Article VII

Each state party, within the purview of exercising its national sovereignty, has the right to withdraw from this treaty if it decides that exceptional circumstances exist related to upholding the treaty, that would threaten its supreme interests. It will notify the UN Secretary General of its decision six months prior to withdrawal from

the treaty. Such notification must contain a statement as to the exceptional circumstances which the notifying state party considers as threatening its supreme interests.

Article VIII

1. This treaty is open to all states for signature at the central headquarters of the United Nations in New York. Any state that does not sign this treaty prior to its entry into force pursuant to paragraph 3 of this article may accede to it at any time.

2. This treaty is subject to ratification by the signatory states. Instruments of ratification and accession must be deposited with the Secretary General of the United Nations.

3. This treaty enters into force between the states that have deposited their instruments of ratification after such time as the fifth instrument of ratification has been deposited with the Secretary General of the United Nations.

4. For states whose instruments of ratification are deposited after entry into force of this treaty, it will enter into force on the day their instruments of ratification or accession are deposited.

5. The Secretary General of the United Nations will notify without delay all signatory and acceding states as to the date of each signature, the date of deposit of each set of instruments of ratification and accession, and the date of entry into force of this treaty, as well as other information.

Article IX

This treaty, the Russian, English, Arabic, Spanish, Chinese and French texts of which are equally authentic, will be deposited with the Secretary General of the United Nations, who will forward duly certified copies of the treaty to the governments of the signatory and acceding states.

9768
CSO: 1866/159

DISCUSSION OF SOVIET POLICY ON PEACEFUL USE OF OUTER SPACE

Moscow INTERNATIONAL AFFAIRS in English No 7, Jul 81 pp 62-69

[Article by S. Stashevsky: "The USSR in the Struggle for a Peaceful Outer Space"]

[Text] The USSR efforts to keep outer space demilitarized and turn it into a zone of peace and the exclusively peaceful activity of man are a component of the struggle for peace and disarmament. The USSR consistently works for the establishment of an international legal order where the exploration and utilization of outer space would serve peaceful purposes only. These efforts met the interests of all nations and enjoy widespread international support.

A number of international agreements have been signed as a result of the active efforts of the Soviet Union and the other socialist countries and peaceloving states. They impede directly or indirectly the use of outer space for military purposes and in some ways limit the arms race there. These agreements provide a solid foundation for the demilitarization of outer space and for removing it from the military sphere.

The technological revolution and the development of astronautics open up truly inexhaustible possibilities not only for research in outer space but also for extensive space exploration and the application of space technology for practical needs like navigation, communication, weather forecasting, observation of the Earth's flora, prospecting for mineral resources, planning of farm fields and forests, to mention but a few.

At the same time outer space provides many possibilities in the military field. Through it pass the trajectories of intercontinental ballistic missiles (ICBMs), the most powerful and destructive modern weapons. Other forms of the military application of space technology, examined in the Western press, include the use of satellites for troop control, reconnaissance, the development of spacecraft for conducting combat operations in or from outer space (interceptor satellites, orbital strike weapon systems, etc.).[1]

Rupturing detente and escalating the arms race, the US militarist circles continue improving and building up nuclear missile systems (development of the MX missile, improvement of the ICBMs accuracy). Moreover, they are increasingly revealing a desire to begin militarizing outer space by way of building new types of space-based weaponry with particular emphasis on the development of a range of spacecraft capable of performing military missions.

The Pentagon is intent on the idea of creating a new space transport system that would in a few years' time be the basis of American military space programmes. What is meant is the Space Shuttle, a manned spaceship of multiple usage. The Columbia space shuttle with two astronauts on board made its first flight recently.

The Shuttle programme is subordinated to the interests of the US military agencies, and due to this reason a short list of peaceful experiments, which were to be conducted with the help of the Shuttle, keeps shrinking every day. In fact, it is the Pentagon which administers the entire programme. The Shuttle programme for the next few years alone envisages more than 100 "military missions" where over half of the system's carrying capacity is reserved for military purposes.

Multiple usage of the same orbital craft makes the Shuttle basically different from other transport systems available today. Its flight system consists of an orbital craft slightly resembling an ordinary medium-sized transport aircraft with triangular-shaped wings, an external fuel tank and two solid fuel rockets. The orbital craft and the rockets are designed for multiple use while the external tank can be used only once. The Shuttle returns to Earth and flies in the atmosphere using such features of its design as the lift force created by its wings, which results in a much longer trajectory of its return flight compared to that of the recovery capsule of ordinary rockets. Most of its trajectory lies at relatively low altitudes over the territories of foreign states, something that poses a number of problems pertaining to international law.

What alarms the world public most is the plans of the Pentagon strategists to use the Shuttle in implementing their new far-reaching military programmes in outer space. In addition, it can put in orbit many "cheap" spy satellites as well as satellites concerned with military communication, navigation, weather and geodesy and other military purposes. The Shuttle provides the basis for a new anti-satellite system.[2] It is believed that special devices will enable it to "inspect" space objects on orbit, remove them from orbit, and destroy them or take them down to Earth in the cargo compartment. The spaceship is supposed to be equipped with laser weapons. US military experts are considering using it for placing nuclear devices in outer space. The Pentagon also pins great hopes on the Shuttle in the matter of deploying a space-based anti-missile defence system. With this aim in view it plans to build 10 permanent orbital stations over the next 15 years and arm them with powerful chemical lasers to destroy the warheads of the "enemy's" ICBMs in flight.

Retired Lieutenant General Daniel O. Graham, the former head of Defense Intelligence Agency, stated recently: "Eventually we will have a very significant part of our military capability in space."[3] The Space Shuttle helps to bring this day closer.

The USA is developing other anti-satellite systems as well. One of them envisages the use of miniature missiles launched from F-15 fighters flying at high altitudes. In 1981, $128,6 million have been earmarked for this programme as compared to $73 million in the 1979 fiscal year.[4] Reports point to another system where small anti-satellites would be launched by the Minuteman-3 missiles. Still another military space programme, estimated at about $1,000 million annually, provides for the siting of powerful lasers on high mountain summits to destroy low-orbit satellites.

All these projects pursue the aim of gaining military superiority over the USSR in outer space and obtaining unilateral advantages for the USA.

A concrete programme of complete demilitarisation of outer space was put forward by the Soviet Union in the disarmament memorandum of March 15, 1958, right after it had launched the world's first Earth satellite and demonstrated its capability of building intercontinental ballistic missiles. The Soviet Union proposed a ban on all forms of military activity in outer space without exception, including the use of ICBMs.

The Soviet Union proceeded from the need to consider the security interests of all states, which was why the proposed ban on the use of outer space for military purposes was linked with the elimination of foreign military bases on other countries' territories, the chief source of danger to the USSR's security. However, the proposal submitted to the 13th Session of the UN General Assembly found no support from the USA and its allies. Opposed to practical agreements to this effect, the USA was anxious to obtain unilateral advantages in the military field and to secure a free hand for rapid development and deployment of ICBMs and implementation of several other military space programmes. Hence its proposals on establishing international control over missile launching, advanced at the United Nations in the late 1950s and early 1960s. The idea was to prohibit, limit or put under "international control" the Soviet ICBM military programme as long as the USA had no such missiles at the time.[5]

The American proposals, of course, omitted the dismantling of the numerous military bases spearheaded against the Soviet Union to deliver blows by US aviation to Soviet territory. Actually, they were a propaganda veil for the US nuclear missile buildup rather than a move towards beginning business-like talks.

A programme of general and complete disarmament was later advanced and specified by the Soviet Union at the United Nations. Its implementation would have opened the way towards establishing a regime where outer space would have been used for peaceful purposes only. The Soviet delegation submitted a draft Treaty on the Complete and General Disarmament Under Strict International Control to the Eighteen-Nation Committee on Disarmament on March 15, 1962.[6] The Soviet programme provided for the stage-by-stage destruction of all types of weapons, the disbanding of all armed forces and elimination of all foreign military bases on foreign territories. The liquidation of nuclear weapons was to begin with the destroying and halting of the production of all nuclear weapon-delivery systems, including missiles of all calibres and ranges. Combat missiles were to be destroyed while the launching pads, underground storage, test grounds and the requisite launching and control instruments and equipment were to be either dismantled or, where possible, modified for peaceful needs. The same was to be done with installations necessary for the production of such missiles. Only those launching pads, instruments and equipment were to be spared that could be used for peaceful purposes (Article 15 of the draft Treaty).[7]

Subsequent Soviet proposals for disarmament could just as well have been instrumental in radically solving the problem of banning the military use of outer space. On February 1, 1979, the USSR along with other socialist states, Bulgaria, Czechoslovakia, Hungary, the GDR, Mongolia, and Poland, submitted to the Committee

on Disarmament a proposal for talks on halting the production of all types of nuclear weapons and a gradual reduction of their stockpiles up to their complete destruction. The proposed nuclear disarmament envisaged, among other things, gradual reduction and liquidation of nuclear weapon-delivery vehicles[8] of which the strategic ballistic missiles were the most advanced.

Apart from trying to carry out radical measures in the disarmament sphere that would have made it possible to completely demilitarize outer space, the Soviet Union worked for partial measures to limit the arms race and bring about disarmament. Those efforts, backed by other peaceloving countries, produced concrete results in limiting military activity in outer space.

Firstly, the universal treaties, formalising a wide range of principles and norms of the activity of states in space exploration and utilisation, incorporated norms prohibiting certain types of the military use of outer space.

Secondly, the provisions of some multilateral international agreements on partial measures in the sphere of disarmament extend to outer space.

Thirdly, the Soviet-American agreements on the limitation of anti-ballistic missile systems (1972 and 1974) and on the limitation of the strategic offensive arms, signed in 1972 and 1979, include corresponding provisions imposing quantitative as well as qualitative ceilings on certain types of weapons intended for use in outer space.

An important step towards limiting the military use of outher space is envisaged in the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, which came into force on October 10, 1963. Article 1 contains a commitment on the part of the states parties to the Treaty to ban, to prevent, and not to carry out any nuclear weapon test explosions or any other nuclear explosions in the three media--under water, in the atmosphere and in outer space.

The ban on nuclear tests in outer space has become a widely accepted norm of international law and a part of the law on outer space. To be more effective, the Treaty should be universal, that is, it should be acceded to by all nuclear powers. Of the nuclear states, only China and France have not signed it as yet.

Of special importance for limiting military activity in outer space is the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, worked out on the Soviet Union's initiative at the UN Committee on the Peaceful Uses of Outer Space in 1966. The General Assembly, in its Resolution 2222 (XXI) of December 19, 1966, unanimously approved the text of the Treaty and recommended that the depository states--the USSR, the USA and Britain--open it for signing and ratification. Over 80 countries have joined it since October 10, 1967, when it entered into force.

The elaboration of the Treaty was a hard battle, which was at its fiercest where its basic provisions were concerned. In the early 1960s the USA, which sought to get a "free hand" in developing its military space programmes aimed at attaining military superiority over the USSR, held a negative stand on the issue of international legal commitments in outer space. It became clear by 1966 that should a

nuclear arms race get under way in outer space, it would not give the US advantages for which the aggressive military circles in that country had hoped originally. In that context, the USA had to comply with the demand of the peace forces and join the efforts to work out a treaty that would clearly formulate an international legal regime in outer space.

The Soviet Union sought to achieve the demilitarization of outer space to the greatest extent possible under the circumstances. This was the aim of the basic provisions and legal norms contained in its draft document, which would regulate the activities of states in outer space, on the Moon and other celestial bodies. In submitting the draft, the Soviet Union proceeded from the common interest of mankind in the peaceful exploration of outer space.

The American draft Treaty, unlike the Soviet one, mentioned the Moon and other celestial bodies but not outer space as a whole and, thereby, narrowed the scope of the Treaty.

Finally, it was the Soviet draft which the peaceloving states chose as the basis for the text of the treaty.

Alongside the wide range of general rules of conduct in space, the Treaty included provisions on partial demilitarization of that medium and on full demilitarization of the Moon and other celestial bodies. Prominent among them are the commitments of states not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. The Treaty prohibited the "establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies." The Treaty also included the provision of the Soviet draft on the inadmissibility of using outer space for war propaganda.

Thus, the first ever universal treaty on outer space became a significant step towards demilitarizing that medium.

A great achievement in this respect is the 1977 Convention on the Prohibition of the Military or Any Other Hostile Use of Environmental Modification Techniques. Drawn up on the Soviet Union's initiative at the Committee on Disarmament the Convention was adopted by the 31st Session of the UN General Assembly and recommended for signing and ratification.

That was a timely act. It became clear by the early 1970s that scientific and technological progress had provided man with the means of influencing the natural environment, which could be used for military or other hostile purposes. Scientific literature in the West reported about the development of methods to modify near-Earth space and to change the environment on Earth via outer space. It wrote, for instance, that bromic compounds sprayed from satellites in the stratosphere could cut "windows" in the Earth's ozone layer and allow cosmic radiation to easily reach the surface destroying any life on it.[9]

The Convention commits countries signing it "not to engage in military or any other hostile use of the environmental modification techniques having widespread,

long-lasting or severe effects as the means of destruction, damage or injury to any other State Party." Article II of the convention explains that the term environmental modification technique implies "any technique for changing through deliberate manipulation of natural processes--the dynamics, composition or structure of the earth including its biota, lithosphere, hydrosphere and atmosphere or of outer space". The Convention in effect formalizes the principle of the inadmissibility of employing means of modifying outer space for military or other hostile purposes.

Major provisions for materially restricting the use of outer space for military purposes are also contained in bilateral Soviet-American agreements such as the 1972 Treaty on the Limitation of Anti-Ballistic Missile Systems (ABM), and the 1974 Additional Protocol to it, the 1972 Interim Agreement on Certain Measures with Respect to the Limitation of Strategic Offensive Arms (SALT-1) and the Treaty on the Limitation of Strategic Offensive Arms (SALT-2), signed in Vienna on June 18, 1979, which has not yet entered into force because of the position held by the US administration.

The ABM Treaty, for example, substantially limits anti-ballistic missile systems in the USSR and the USA, designed to destroy ICBMs including those flying at high altitudes. Under the Treaty, the USSR and the USA each can have only one area for deploying such weapons, and the number of anti-ballistic missiles at launch sites should not exceed 100. In addition, each party pledged "not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based or mobile land-based". The importance of this international legal prohibition is great, indeed, considering that influential forces in the USA would like to begin building ABM systems in outer space. According to foreign press reports, the USA is also developing a programme of the ABM system based on the use of so-called radiation weapons.[10] It is supposed to be installed on orbital spacecraft and used for destroying the "enemy's" ballistic missiles when still over the "enemy's" territory or over the ocean. According to some foreign experts the work on the radiation weapon in the US has already gone beyond the bounds of purely theoretical research.

Under the 1972 Interim Agreement the parties undertook to limit fixed land-based ICBM launchers and submarine-launched ballistic missile (SLBM) launchers to the numbers operational and under construction on the date of signing the Agreement. That Agreement imposed a sort of a material restriction on using outer space for military purposes.

SALT-2 went further, imposing not only quantitative but also qualitative restrictions on military activity in outer space. With the Treaty coming into force, both parties pledged to limit the number of the land-based ICBM launchers or submarine-launched ballistic missile (SLBM) launchers as well as the number of heavy bombers and air-to-surface ballistic missiles with the range of over 600 kilometers, to a total of not more than 2,400 vehicles. In addition, the treaty limits the possibilities of building means for delivering nuclear weapons to Earth orbit and creating fractional orbital missiles.

Although the above-mentioned treaties have provisions concerning only the USSR and the USA, they play a major role in the entire system of international law in

view of their decisive importance for reducing the danger of nuclear war and safeguarding peace.

The UN General Assembly has on a number of occasions passed resolutions in support of measures to limit the strategic offensive arms. Thus, for instance, the special resolution of the 35th Session of the General Assembly persistently urges no further delay in the coming into force of the SALT-2 Treaty.

A big step toward limiting military activity in outer space was made by the UN Committee on the Peaceful Uses of Outer Space when it worked out an agreement on the activity of states on the Moon and other celestial bodies, drafted by the Soviet Union. In a letter to the UN Secretary-General, Soviet Foreign Minister Andrei Gromyko indicated that as the Earth's natural satellite, the Moon, has an important role to play in space exploration and it should be used exclusively in the interests of peace and for the benefit of the whole of mankind. It is essential that the activities of states on the Moon should not be allowed to become a source of international conflicts and that a legal basis should be established for possible uses of the Moon. The signing of an appropriate international treaty would serve this purpose. A special resolution of the 34th Session of the UN General Assembly endorsed the draft agreement drawn up by the Committee on the Peaceful Uses of Outer Space. The signing of the Treaty Concerning the Moon began on December 18, 1979.

The document reflected and specified as applied to the Moon and other celestial bodies the rules and principles of space law which had been formalised by the 1967 Outer Space Treaty.

Article 3 of the Treaty Concerning the Moon confirms the provision of the Outer Space Treaty that activities on the Moon are to be conducted exclusively for peaceful purposes, and introduces the notion of "circumlunar space". It was essential that in the interests of ensuring international peace and security this aspect be stipulated, since the 1967 Outer Space Treaty only banned the militarization of celestial bodies while establishing the regime of partial demilitarization in outer space (of which circumlunar space is, of course, a part).

The Treaty reflects the great progress achieved lately in the exploration of the Moon as well as mankind's desire that the Moon be exclusively used for peaceful purposes without being turned into a military base and an object of international discord.

In summation, one can see that contemporary international law contains a number of international agreements curbing the military use of outer space. But what restrictions do exist are not complete. There is not as yet a sufficiently reliable legal barrier that would effectively block any way towards using outer space for military purposes.

The Soviet Union is consistently pressing for such a barrier and for effective agreements which could prevent the proliferation of nuclear arms in outer space.

This purpose was served by the Soviet proposal to ban the development and production of new types and systems of mass destruction weapons, advanced by Leonid

Brezhnev at the meeting with the Moscow constituency on June 13, 1975. He said: "What is meant is that states, primarily the big powers, should conclude an agreement prohibiting the creation of new types of mass destruction weapons and new systems of such weapons."[11] The Soviet Union submitted a draft international agreement to this effect to the 30th Session of the UN General Assembly which in turn referred the draft to the Committee on Disarmament urging it to begin as soon as possible formulating the text of such an agreement with the participation of government experts. However, five years of exhaustive discussions in the Committee were fruitless because of the opposition from the USA and other NATO countries. The 35th Session of the UN General Assembly confirmed the fact that the Committee on Disarmament should continue talks with a view to preparing a draft comprehensive agreement on the prohibition of the development and production of new types and systems of mass destruction weapons and also draft agreements on separate types of such weapons.[12] Obviously, the signing of such agreements will considerably promote the cause of demilitarizing outer space.

The Soviet-American negotiations on anti-satellite systems could just as well be regarded as efforts to limit military activity in outer space. The first two rounds of the talks took place in Bern in January-February 1979 and in Vienna in April-June of the same year. The Soviet-American summit meeting at Vienna in June 1979 confirmed the intention of both sides to actively continue the search for mutually acceptable agreements at the negotiations on anti-satellite systems. However, the talks were stalled through the Americans' fault.

Owing to the efforts of the USSR, Soviet-American dialogue was not broken off. The first round of negotiations on the limitation of nuclear arms in Europe took place in Geneva from October 17 to November 14, 1980. The achievement of practical results at these negotiations would not only have been an important measures in curbing the arms race and reducing the danger of nuclear war, but would have largely facilitated the solution of the problem of limiting the use of outer space for military purposes, as medium-range ballistic missiles also figure among those devices which can be utilised in outer space.

The record has shown that if military activity in outer space is to be further limited and then stopped altogether, it is essential to solve the problem of arms limitation and disarmament, especially in the sphere of nuclear weapons, and to ensure international legal guarantees for the security of states. A road to this is shown in the appropriate Soviet proposals for disarmament made at the United Nations, the Committee on Disarmament and other international forums, on a bilateral or multilateral basis.

Now that states' arsenals have various types of weapons, including military space technology, a world treaty on the non-use of force in international relations, worked out and concluded as soon as possible, would create good prospects for restricting and then halting military activity in outer space. The UN is currently working on such a treaty at the USSR's initiative. Article 1 of the Soviet draft treaty submitted to the 31st Session of the UN General Assembly in 1976 proposes that the member states pledge to refrain from using armed forces and any types of weapons, including nuclear and other mass destruction weapons on land, at sea, in the air and outer space, and not to threaten to use them.

The USA, its NATO allies and China are retarding in every way the UN's work on the text of the treaty in spite of the repeated calls of the General Assembly to speed up the preparation of the document. Its 35th Session passed a resolution to this effect.

The United Nations always played a major role in limiting the military use of outer space. The problems of demilitarizing and preventing the arms race in outer space were discussed at the Special Session of the UN General Assembly on Disarmament in May-June 1978. The Soviet Union and other socialist countries took an active part in the discussions. The Final Document of the Special Session reads: "In order to prevent an arms race in outer space, further measures should be taken and appropriate negotiations held in accordance with the spirit of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies."

The UN Committee on the Peaceful Uses of Outer Space has discussed several Soviet initiatives for limiting and prohibiting military activity in outer space. The Committee on Disarmament has worked out or actively helped work out several agreements pertaining to this problem.

Due to resistance from imperialist and hegemonistic forces, no radical turn has been achieved in the matter of disarmament to date. Real progress in checking the arms race would also help radically solve the problem of banning military activity in outer space on a just basis and removing outer space from the military sphere. The positive results achieved in the 1960s and 1970s provide a solid material foundation for a continued struggle for turning outer space into an area of exclusively peaceful cooperation among states, free from military rivalry and conflicts. It opens ways towards the complete demilitarization of outer space through measures for real disarmament.

"We want to achieve a great humane goal through joint effort--to exclude militarization from outer space," said Leonid Brezhnev, the General Secretary of the CPSU Central Committee and Chairman of the Presidium of the USSR Supreme Soviet. The Soviet Union's concrete steps towards broader businesslike cooperation of states in outer space confirm its adherence to this course.

FOOTNOTES

1. See OUTER SPACE--BATTLE FIELD OF THE FUTURE, SIPRI, London 1978.

2. BUSINESS WEEK, June 4, 1979.

3. NEWSWEEK, Apr. 27, 1981.

4. THE NEW YORK TIMES, May 20, 1980.

5. See UN Doc. DC/SC. 1/66.

6. See UN Doc. ENDC/2.

7. Ibidem.

8. See UN Doc. CD/4.

9. See WEAPONS OF MASS DESTRUCTION AND THE ENVIRONMENT, SIPRI, London, 1977, p. 50; UNLESS PEACE COMES, New York, 1968, pp. 191, 238.

10. AVIATION WEEK AND SPACE TECHNOLOGY, No. 10, Vol. 105, 1976, pp. 30-34.

11. PRAVDA, June 14, 1975.

12. UN Doc. A/RES. 35/149.

CSO: 1852/6

LT GEN AVN TITOV ON FUTURE OF COSMONAUTICS

Moscow SOVIET MILITARY REVIEW in English No 3, Mar 81 pp 9-12

[Commentary by Lt Gen Avn G. S. Titov: "Space Trails"]

[Excerpt] Yuri Gagarin wanted to devote his life, work, thoughts and senses to the new science dealing with space exploration. He wanted to go to Venus to see what lies behind its clouds, to visit Mars and see with his own eyes if it really had canals. And though his dream did not come true, a new generation of cosmonauts will make it reality.

Space conquest is a single rhythmic steadily ascendant movement. Space flights contribute much to modern science. Nowadays space study is on an equal footing with other research activities.

The results of space study broaden the possibilities of TV and communication, give warning of storms, are used for navigation, in geological prospecting, agriculture and other branches of the national economy.

These flights give birth to new ideas and considerations and sometimes the necessity arises to perform experiments which have not been planned. Space flight conditions are constantly used to study the adaptability of the human beings and other living organisms. This is essential for preparing the crews for prolonged space flights, for extending our knowledge in the field of medicine, and for developing means and methods of overcoming the unfavourable effects of space flight on living organisms. Concurrent with improvement of the space apparatuses which have been already used to investigate the Moon, Mars and Venus, and of Intercosmos satellites, automatic Prognoz high-apogee observatories, cargo and transport spacecraft of the Soyuz T and Progress classes and others, new space vehicles will be developed to explore the planets of the Solar system.

This will promote better understanding of the evolution of nature on other planets, help to obtain new information on the structure of the earth and its atmosphere and additional data on natural resources, means of protecting the environment, on the state and changes in physical and biological characteristics of the surface layers of the World Ocean.

Scientists will want to make a deeper study of the relations between the Sun and the Earth and of the cosmic phenomena in nature to extend their knowledge of the surrounding world and to solve many practical problems.

As Yuri Gagarin foresaw, man's role in space research is steadily growing, and we will face even more splendid tasks in the near future.

Men have already adapted to space, they can live and work there for prolonged periods of time. This has been proved by the prolonged flights of P. Klimuk and V. Sevastyanov (64 days), Yu. Romanenko and Yu. Grechko (96 days), V. Kovalyonok and A. Ivanchenkov (140 days), V. Lyakhov and V. Ryumin (175 days). L. Popov and V. Ryumin recently set a new record by working in a state of weightlessness for 185 days.

The Salyut-6 spacecraft which has been orbiting the earth since September 29, 1977, has proved the practicability of prolonged expeditions. Its crews are formed so as to include at least one cosmonaut who already has experience of work on the station.

The space laboratory has been visited by specialists from the majority of socialist countries. These fraternal ties are being strengthened from year to year; they contribute to greater closeness and mutual understanding and to the solution of urgent problems interesting the whole of mankind.

Space flights will become an ordinary thing in the future. But in our days they are outstanding event, a step into the unknown. They require of cosmonauts boundless courage, high skill and strong will power.

Only reliable spaceships with completely automatic working processes and comprehensively trained cosmonauts can ensure success of space flights.

Account must be also taken of the cosmonaut's health because nobody can guarantee that he will not fall ill in space. While the spacecraft orbits the earth it is not dangerous because the crew can be quickly returned. But what if they are on the way to another planet? Everything must be foreseen in that case, and first of all it is necessary to find medicines which will enable the crews of, for instance, future interplanet spacecraft and the personnel of lunar settlements and large near-space orbital stations to live and work for long periods without illness.

In prolonged flights the cosmonauts must get accustomed not only to the inconveniences caused by weightlessness and to the narrow confinements of the station but also to the prescribed rhythm of life and strenuous work. The necessity for prolonged flights is evident, because they are more justified economically. It has been established that after several months' stay in outer space man has completely adapted himself to weightlessness and begins to work at full capacity.

It is not yet known for sure what can be the consequences of prolonged weightlessness, isolation from society and confinement in reduced living space. Information provided by medical examination of cosmonauts who had stayed in outer space for a long time will be of paramount importance for further development of world cosmonautics.

Twenty years have elapsed since the day when Yuri Gagarin set off in a spaceship round the earth. He made man's first step into the stellar ocean. The further the event of April 12, 1961, recedes irto the past, the more majestic it seems to us. That was the beginning of manned space flights. Not long has passed since that time from the historical point of view, but space exploration already has a firm place in our life. It has become one of the most important fields of human activity.

CSO: 1852/3

PRESIDENT OF USSR ACADEMY OF SCIENCES ON ACCOMPLISHMENTS OF SOVIET COSMONAUTICS

Moscow IZVESTIYA in Russian 11 Apr 81 p 3

[Article by A. Aleksandrov, academician, president of the USSR Academy of Sciences: "Man's Springtime in Outer Space"]

[Text] This year's celebration of Cosmonautics Day comes in a significant period. The 16th CPSU Congress recently completed its work. In his summary report to the CC CPSU, Lenoid Il'ich Brezhnev noted the successes of the Soviet cosmonautics, its great political and national economic significance.

The achievements of cosmonautics are related in a practical sense to the entire course of scientific and technological progress. In essence, the very fact of the development of cosmonautics can be seen as a composite indicator of the power of our country's means of production, of its scientific and technical potential, of the high degree of development of its economy, and of the overall educational and cultural level of its people.

Space flight has been man's dream for centuries. Twenty years ago the world witnessed its first flight in outer space. Launched around the earth from a Soviet cosmodrome, using a Soviet rocket, Citizen of the Soviet Union Yuriy Alekseyevich Gagarin accomplished this flight on board the Soviet ship "Vostok." The flight lasted 108 minutes and introduced the era of man's penetration of space. A vast period of preparation preceded this amazing achievement, a period linked with the development of ideas, methods and means for space exploration.

The matter of reaching high altitudes through the use of rockets was brought up in this country in the beginning of the 1930's. A fundamental contribution towards practical realization of the idea of rocket flight was made for the first time by Soviet rocket construction design and experimentation organizations--the Gas Dynamics Laboratory (GDL) and the Study Group for Jet Propulsion (GIRD). These groups were combined in 1933 to form the first National Scientific Research Institute for Jet Propulsion (RNII) in the world.

Beginning in 1949, a sequential program of studying the upper layers of our atmosphere has been operating that uses exploratory rockets--these have come to be known as "academy" rockets.

Paths of cosmonautics development are taking shape; a program for outer space exploration is being set up. A tremendous contribution in determining basic tasks in the study of space, in solving fundamental problems related to accomplishing the Soviet space program, in creating new methods and means for exploring outer space, has been made by the academician M. V. Keldysh. The development of a number of spheres of science and technology--in particular, a complex of computational devices without which achieving space flight and progress in cosmonautics would be unthinkable--is inseparably linked with his efforts.

One of the founders of practical cosmonautics is the academician S. P. Korolev, chief designer of powerful rockets, of the first artificial earth satellites, and, later on, of autonomous interplanetary stations and manned spacecraft. Formation of the powerful Soviet rocket and space industry is associated with the name of S. P. Korolev and his comrades, who today are the directors of large collectives working on the problems of cosmonautics.

The 20 years following Yuriy Gagarin's triumphal flight have been filled with the intensive and fruitful labor of Soviet space researchers. From being an exceptional event, entry into outer space has turned into a constantly-occurring phenomenon, and the conquest of space for peaceful purposes has taken a systematic and businesslike track. Today Soviet cosmonautics comprises powerful rockets, satellites, autonomous interplanetary stations, manned spacecraft and orbital stations. It is radio and television communications, and navigation over extraordinarily long distances, the collection of meteorological information on a global level, the study of the natural environment and of the earth's natural resources, and it is the solving of many of the fundamental problems of science.

At the present time, when flights of scientific orbital stations have become regular events, and with their scientific and economic effect being perceived in real terms, we can, with great understanding, evaluate the significance of our space achievements over the period that preceded the appearance of these stations.

Problems of a long-range nature were being solved as far back as during the first manned flights of "Vostok" spacecraft. The "Vostok" program became, in essence, the foundation upon which the subsequent development of Soviet cosmonautics is based. During completion of this program, major questions in spacecraft design were answered, and the basic stages of orbital flight were researched. It became clear in which direction we should proceed to develop and perfect space technology, which tasks to assign our cosmonauts.

It became an ever more indisputable fact that man's complete conquest of near-earth space was possible only with the introduction of long-term orbital stations. Our manned space flight program therefore set as its next goal the systematic resolution of all problems related to developing these stations. There were a great number of such problems--orbital maneuvering, search, rendezvous and docking of spacecraft, transfer of cosmonauts from one ship to another. An immediate prologue to building the stations was docking of the "Soyuz-4" and "Soyuz-5" spacecraft, as a result of which experimental space stations appeared in orbit for the first time, as well as the group flight of "Soyuz-6," "Soyuz-7" and "Soyuz-8." After completion of these experiments, Comrade L. I. Brezhnev noted: "Soviet science regards the building of orbital stations with interchangeable crews as man's highway into space."

Along with an increase in the duration of flights and an increased complexity of tasks to be accomplished, matters of providing for the health and efficiency of space crews acquired ever greated significance. The 18-day flight of Andriyan Nikolayev and Vitaliy Sevast'yanov showed that cosmonauts could function successfully under conditions of continued weightlessness. At the same time it became clear that the problem of readapting to earth conditions after a lengthy stay in space demanded the serious attention of scientists.

The flights of the manned spacecraft "Soyuz-10" and "Soyuz-11," and of the first manned orbital station "Salyut" were the next important stage in the development of a new manned space system--the ship "Soyuz" and the orbital station "Salyut." The watch on board this system--of cosmonauts Georgiy Dobrovol'skiy, Vladislav Volkov and Viktor Patsayev--lasted 23 days. Thus, the efforts of Soviet scientists, designers and laborers, resulted in creation of the first base for earthmen in orbit.

On 26 December 1974, the "Salyut-4" space station was launched into near-earth orbit. Its first crew--Aleksey Gubarev and Georgiy Grechko--worked on board for 30 days. The second crew--Petr Klimuk and Vitaliy Sevast'yanov--spent 63 days in space. The programs for these expeditions were filled with experiments and observations. Once again the flight of "Salyut-4" showed convincingly the prospects in store for man's highway in conquering outer space--the building of orbital stations with interchangeable crews.

Flight of the "Salyut-6" orbital station has continued now for three-and-a-half years. The station operated in the manned mode for over a year-and-a-half, during which period 24 cosmonauts conducted on-board research. The duration over which work of the basic expeditions was conducted at the station grew continuously--96, 140, 175 and 185 days. On eight occasions ships with international crews left Baykonur. Add to this the flight of Vladimir Dzhanibekov and Oleg Makarov, of Yuriy Malyshev and Vladimir Aksenov, of Leonid Kizim, Gennadiy Strekalov and once again Oleg Makarov, and the docking of 12 "Progress" spacecraft. All in all, more than 30 of such dockings were accomplished. Today the crew of Vladimir Kovalenok and Viktor Savinykh are working on board the station.

In building "Salyut-6," the original estimate of service life for the station's systems was one-and-a-half years. Today this term has been more than twice surpassed. This was made possible thanks to long-range concepts put into the station's design. Two docking units enable the reception of cargo transport ships even when one of the docking units is occupied with a "Soyuz" craft that has delivered a crew into orbit. "Progress" ships deliver fuel, provisions, water, oxygen, repair assemblies--everything that is necessary for continuation of the scientific program: sound and picture recording film, technical experiment capsules, containers with biological subjects. In all, the "Progress" ships put into orbit more than 20 tons of various freight. Periodically the crews replaced worn-out systems with new ones. Instruments and assemblies appeared on board, many of which existed only on the drawing board at the time the station was launched, or even were only in the minds of scientists and designers at the time. This was the case, for example, with the KRT-10 space radiotelescope. All in all, the cosmonauts worked not with outdated or obsolete equipment, but with the most modern. They conducted a great volume of research. Judge for yourself. The first "Salyut-4" expedition--Aleksey Gubarev and Georgiy Grechko--completed national economy-oriented tasks in the interests of 40 of our

country's organizations and departments. The economic effect of the work performed by both of this station's expeditions amounted to 50-70 million rubles. Today over 400 organizations are utilizing information received from on board the "Salyut-6" orbital station.

Two interrelated natural-science missions were carried out on board the "Salyut-6" station: visual and instrumental observations of the natural environment using hand-held photographic equipment and filming of the earth's surface with the fixed KATE-140 and MKF-6M devices. The cosmonauts spent about 30 percent of their entire working time on research in the natural sciences.

It should be pointed out that, in developing the economic research program for "Salyut-6," the submitted requests of several hundred organizations of 22 of the country's ministries and departments were used, as well as requests filed by the socialist countries, many of which were satisfied during an international-crew period of operation.

For the first time, such complex instruments as the BST-1 sub-millimeter telescope and the KRT-10 radiotelescope were tested on board "Salyut-6." These instruments are suited for handling both fundamental and national-economic tasks.

Experimental work conducted with the KRT-10, the first space radiotelescope, showed especially great prospects for the future. One of the areas of research involves the possibilities for studying the earth and the ocean in the interests of the national economy. The most important particular feature here is the fact that the research can be conducted under any conditions of weather (clouds are transparent for radio waves) and at any time of day or night. Another area is radio astronomy observations--first and foremost, the building of an interferometer using a ground-based and space telescope. Prospects are apparently opening up in this regard for an unlimited increase in angular resolution for astronomy.

No less important was a series of experiments conducted on "Salyut-6" with the aim of obtaining new materials and completing a number of industrial processes whose accomplishment on earth is impossible due to the influence of gravity and the absence of a complete vacuum.

The experience of conducting experiments in space shows with every degree of confidence that international cooperation in space is only a matter of time, and is the objective tendency of modern science and technology. The Soviet Union believes that the achievements of cosmonautics are in fact the common property of mankind, a contribution to the cause of strengthening peace in the name of progress, to the cause of promoting the happiness and welfare of people on earth. It is for precisely this reason that our country is making every effort to broaden international cooperation with many nations in the study and conquest of space.

Along with Soviet cosmonauts, envoys from Czechoslovakia, Poland, the German Democratic Republic, Bulgaria, Hungary, Vietnam, Cuba and Mongolia accomplished flights in space. The results of each flight have become the property of all participants in the "Intercosmos" program.

It should be emphasized that these flights have a continuity--they comprise a kind of relay race for studies and research conducted in orbit. Thus, the experiments prepared by scientists of Czechoslovakia were successfully continued by a Soviet-Polish crew. Vietnamese and Cuban cosmonauts operated with equipment developed by Bulgarian scientists. Other internationally-composed duty shifts, "Intercosmos" colleagues on board the "Salyut"-"Soyuz" scientific complex, were no less fruitful by virtue of their daring originality of ideas put into practice.

One of the particular features of the "Salyut-6" flight is the fact that each expedition--to include the international ones--added in turn its own scientific equipment and instrumentation to that which was already on board the station. Due to this, the scope of scientific research conducted was significantly broadened.

A great many examples can be cited to characterize the effectiveness of the studies and research accomplished on the station--results of space technology experimentation, information on conditions deep within the earth obtained as a result of remote sounding from space, and much more. But the mission of orbital flight lies not only in obtaining such data, important as that is. What is happening today is the intensive exploration of a new world that mankind has penetrated, the accumulation of information as to how successfully man will be able to live and work there. Therefore, the matter of medical and biological research on board orbital stations is, at the current stage, a matter of primary importance, one with great scientific as well as practical significance.

At the current stage of development in cosmonautics, a major purpose of the research is to understand all the possible negative consequences of man's stay in a world of weightlessness, and to develop the antidotes. This is an important task for our entire civilization, whose future is closely linked with the conquest of outer space, with the setting-up of orbital plants, energy-producing factories, and near-earth scientific settlements. In our eyes it is right now that the foundation for the future of cosmonautics is being laid, that the necessary measures, life and work modes are being worked out to provide the capability for people to spend long periods in space. In this regard it should be stressed that a joining of forces to solve the problems of medicine in space would serve to the benefit of all mankind.

Man is capable of conquering outer space only if he learns how to function there and remain healthy. Then, after returning to conditions of earth gravity, he must be able to regain his pre-flight condition within a short period of time. Prior to the flight of Yuriy Gagarin, the question was--can man live and work in a condition of weightlessness? Now it would be formulated differently--how long can man live and work in space without causing damage to his health? To answer this requires a knowledge of how man gets accustomed to weightlessness, how the reactions of the human organism change under space-flight conditions, how effective are preventive measures directed towards sustaining and supporting the health and working efficiency of a crew in flight, what should be the cosmonauts' mode of operation--their work and rest periods--how should their physical and specialized exercises be alternated so as to reduce the effect of in-flight conditions on their organism.

The cosmonauts' long-term flights on board the Soviet "Salyut" orbital stations have assisted in obtaining the information necessary to answer these questions. It is not only a matter of the crew conducting numerous scientific and technical experi-

ments, but also the fact that the men themselves have become the subject of intense observation and in-depth investigation by doctors.

If you add up all the days spent on "Salyut-6" by the four basic expeditions, you get more than a year and a half of uninterrupted work. Valeriy Ryumin has registered 362 days in space--a record that will hardly be broken any time soon. This is something cosmonautics in our world has not yet seen, and we are entirely correct in speaking about a unique experience. Today we can say with certainty that the basic technological and physical problems associated with sustaining long-term human flight in space have been overcome. Of course it is still too early to talk about weightlessness as having been conquered completely, but successes achieved with regard to the medical aspect of space flight are quite significant.

What are the prospects for the further development of orbital stations? The vehicle assemblies we have today--relatively small in size but long-lasting--that are outfitted with one or several docking units, enabling new instrumentation and equipment blocks to be anchored to the station, have proved their worth completely. The basic purpose of these stations is to give a start in life to newer and newer kinds of scientific research, to develop measurement techniques and methods, and to perfect the equipment designated for this.

As time goes by, specialized stations will appear for conducting projects in the sphere of space technology; medical and biological laboratories will be built. Heavy orbital stations will be launched into orbit having the capability to support long-term astrophysical observations of the most interesting objects in space simultaneously over many electromagnetic wave bands. Building such stations is a most complicated engineering and technological task. Required in this regard are all-encompassing preparation, development of a precise strategy of research, a search for the most efficient ways to utilize orbital stations, a true determination of man's role in fulfilling a program of experiments.

Autonomous space scout vehicles will be developed and perfected too. Automatic equipment was, and remains, a reliable tool for acquiring knowledge of the universe, for subjugating it. With the help of autonomous space stations, a broad complex of scientific research can be accomplished--from reception of the very first "sounding" information right up to a systematic and thorough study of the heavenly bodies and physical processes in space.

In 1957 only two sputniks were launched into near-earth orbit. By the end of the 10th year of the space age, the total number of launches of autonomous space vehicles in the USSR exceeded 600. Right now if we consider only launches of the "Cosmos" series--there have been over 1200. And then there are the "Polet," "Elektron," "Prognoz," "Proton," and "Intercosmos" satellites.

In 1959, direct investigation of that heavenly body near to us--the moon--was begun by the first autonomous interplanetary stations (AIS). Development of the AIS series "Luna," [moon] "Mars" and "Venera" [Venus], begun under the direction of the academician S. P. Korolev, was successfully continued by a collective headed by the talanted designer and associate member of the USSR Academy of Sciences, G. N. Babakin. The collective built successive generations of complex, automated space robots. Also worthy of note is the activity of a most prominent designer of space

rocket systems, the academician M. K. Yangel', whose efforts were exceptionally significant in developing equipment for the study of near-earth space.

Over the past few years we have received unique experimental data that have greatly changed our concepts as to the nature of the earth's environs--both near and far--and of our neighboring heavenly bodies.

The soft landings executed by our automatic stations have made it possible to study the structure of the lunar surface, the chemical and mineral composition of its soil. The insertion of artificial satellites into orbit around the moon has enabled us to conduct studies concerning the magnetic field and the meteor and radiation environment of near-moon space, as well as gamma radiation on the moon's surface. We were witnesses to the magnificent flights of the Soviet autonomous space stations, which, having completed the earth-to-moon journey and return, brought back to earth samples of lunar rock, including some from the subsoil region that were difficult to obtain. The self-propelled "Lunokhod" vehicles also operated on the surface of our natural satellite.

One of the basic tracks of the Soviet space program is study of the planet Venus. This is highly significant, for Venus belongs to our group of planets, is a close neighbor to the earth and very similar to it in mass and dimensions and at the same time exhibits substantial differences. Defining more precisely the nature of these differences and explaining them will be determining factors in developing a theory of planet evolution.

As long ago as 1967 "Venera-4" conducted direct research in the atmosphere of this mysterious planet for the first time. Since then, research has been on-going as part of an ever more complex program.

Along with finding solutions to the fundamental problems of science, which will always remain at the center of attention in space research, actions are being planned to significantly broaden the application of space achievements in meeting the needs of the national economy. Five years ago the Soviet Union began its launches of communications satellites--"Raduga" [rainbow], then "Ekran" [shield] and "Gorizont" [horizon]--into geostationary orbit. Along with the conventional communications satellites, more than 40 "Molniya-1" [lightning], "Molniya-2" and "Molniya-3" satellites have been launched over these years. Space systems have enabled us to provide central transmission of television programs for 93 percent of the population. Development of our country's economy, primarily the economic assimilation of new regions in Siberia, the far eastern regions and Central Asia, requires that we broaden our communications network.

Systematic space research will be conducted in the interests of meteorology and other branches of knowledge related to the study and efficient utilization of our surrounding natural environment. Even today, weather predictions based on data obtained from space enable us to save material valuables amounting to 500-700 million rubles each year. The benefits of space-obtained data are not only of immediate value--providing warning as to the formation of hurricanes and cyclones, and of their movement--but have a long-term aspect as well. We can accumulate data that will help us to develop more sophisticated methods for predicting the weather and calculating climatic changes.

We will soon be able to expect the organization of a new space service--a service related to the earth's natural resources. It will be just as "established" a service as those which exist today--space meteorology, for example--but its tasks will be wider in scope with respect to regulating man's economic and managerial activity on the land mass and on the sea. The further sophistication of satellite navigation systems is also being planned.

The 26th CPSU Congress has determined new missions for Soviet science and technology in achieving the goals of the 11-th Five-Year Plan. The Soviet people are actively continuing their building of communism. In comprehensively expanding their research on the natural laws of our environment and our society, Soviet scientists must concentrate their attention on the critical problems of science and technology and social progress. Accelerated development of the economy, of our culture and of science itself depends on the solution to these problems. Soviet cosmonautics plays an important role in all of this, and has been consigned to the service of the Soviet people and all of mankind, in the name of the happiness and welfare of people on earth.

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COMMENTARY ON U.S. NAVSTAR NAVIGATION SATELLITE SYSTEM

Moscow ZARUBEZHNOYE VOYENNOYE OBOZRENIYE in Russian No 4, Apr 81 pp 23-28

[Article by Engineer-Colonel A. Kondrat'yev: "NavStar Satellite Navigation System"]

[Text] The U. S. armed forces headquarters feels that the effectiveness of application of strategic and tactical weapons systems is mainly determined by the operational quality of navigational complexes of mobile combat capabilities.

Space navigation systems appeared in the late fifties. Thanks to their advantages they initially became the major means of correcting inertial guidance systems of submarines and surface vessels, and are now considered the principal source of navigational information for aerospace vehicles as well, and also for ground troops and topogeodetic surveys.

The Transit satellite navigation system was created in 1959-1964, primarily for navigation of submarines and surface vessels.* As it was a narrowly specialized system, it could not fully meet current and long-range requirements of flightcraft with respect to periodicity and rate of transmission of navigational data or makeup of information. This made it necessary to develop a fundamentally new system.

In the opinion of U.S. military experts, the prospective satellite navigation system must ensure determination of coordinates and velocity with high precision, must have an adequate level of universality with respect to the area of combat use, and must provide navigational data in near-real time.

The first principle is an obligatory requirement of military navigational systems. The second principle means adaptability to utilization by different kinds of armed forces. The third presupposes the capability of continuous reception of navigational information at any time regardless of the relative positions of satellite and observed vehicle, as well as a high rate of determination of coordinates and other parameters of motion.

The requirement embodied in the third principle is equally applicable to both tactical and strategic mobile combat capabilities. Thus, in addition to giving the prospective satellite navigation system universal properties with respect to its

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*For details see ZARUBEZHNOYE VOYENNOYE OBOZRENIYE, No 4, 1980, pp 65-70. Ed.

users, it should combine the jobs of navigation of tactical and strategic mobile combat capabilities.

Considerable attention is given in prospective navigational systems to complete automation of processes of obtaining and processing navigational information. The mode of passive operation that does not lead to decamouflage of the observed vehicles (a must for military radionavigation systems) is also a requirement that is imposed on the prospective system.

In October 1973, after several years of parallel studies by the United States Air Force and Navy in the area of developing a prospective navigational system, the Department of Defense decided to develop a worldwide satellite system for navigation and position determination intended for servicing all branches of the armed forces. The air force was entrusted with realization of the project, which was dubbed NavStar. To supervise the development, a joint agency was set up, including representatives of the air force, navy, army, and also the marines.

Investigations on the stage of working out requirements enabled determination in the armed forces of the United States of the class of potential users of NavStar, for whom the use of the navigational data provided by the system would be feasible and would ensure problem handling with greater efficiency or on a new qualitative level. In the opinion of U.S. military experts, NavStar will have a major role in implementation of the concept of pinpoint targeting weaponry advanced several years ago in the United States as one of the major areas of development of armament. Potential users of the system are: surface transport, marine and aerospace vehicles. According to estimates of foreign military specialists, the system will be utilized by about 27,000 users in all branches of the U.S. armed forces.

Side by side with such conventional jobs as navigation of various classes of ships and submarines, and determination of their position by units of ground troops, NavStar can handle a number of new jobs: navigational support of aircraft and helicopters, precision delivery of a warhead to a target, control of space vehicle flight, including the Shuttle space transport vehicle on stages of orbital flight and landing, determination of their location by mobile capabilities of ground troops, support of rescue operations, making trajectory measurements in launching of ballistic missiles and payload-carrier rockets, performance of unified time service functions and so on. U.S. military experts are especially emphasizing jobs associated with precision delivery of a warhead to a target. Among these jobs are: placement of the carrier with warhead in a predetermined territory with high accuracy (e. g. placement of an aircraft at a bombing point, or at a point for launching air-to-ground missiles); guidance of the striking capabilities themselves (airborne missiles or the warheads of ballistic missiles). Data obtained from NavStar enable determination of the actual flight trajectory on board the missile or warhead for purposes of correction by means of the airborne propulsion unit. The observed vehicle receives exact unified time signals and navigational information with respect to which it determines its own coordinates along three axes as well as velocity of motion.

According to reports in the foreign press, work on NavStar is being done in three stages.

The first (1975-1980) is planning and development of experimental computer-reception equipment for observed vehicles, creation of the prototype navigational satellite, launching of six prototype models in 1978-1980 (two in each orbital plane), checking out the concept of the system under real conditions, confirmation of the feasibility of reaching goal characteristics, testing components of the system before making the decision to start series production. The cost of the work on this stage is 150 million dollars.

The second (1981-1983) is increasing the number of satellites in orbit to simulate operation of the system in full deployment as a basis for further working tests and to provide limited operational use.

The third (1986-1987) is full deployment of the system.

Overall expenditures on the NavStar project (for a ten-year period of operational use of the system) are estimated at approximately 8 billion dollars.

The system contains three major components: the satellite group, ground-based special control stations, and the computer-reception equipment of the observed vehicles.

The original project called for using 24 satellites (eight apiece in three orbits in planes separated by 120° in space). The orbits are circular, 20,000 km above the earth, inclination of the orbital plane to the equator 63°, period of revolution 12 hours. For purposes of economy, the Department of Defense has now decided to reduce the number of satellites in the operational system to 18 (six in each of the originally chosen orbits, or three in each of six orbits with planes separated by 60°). It is possible that the number of satellites will eventually be brought up to 24.

Both versions of ballistic construction of the system permit gradual deployment. Even three satellites are sufficient for initial operation, although this number can determine only geographic coordinates (latitude and longitude) with long time intervals between observations. As the number of satellites increases, the time intervals between observations will get shorter, and the observed vehicle will determine a third coordinate--altitude--as well. According to data of the foreign press, an experimental system of six satellites (first stage) enables the user to determine his geographic coordinates with a certain periodicity, and to determine his altitude much less frequently (when in the field of view of four satellites). When 9-11 satellites are available (second stage), geographic coordinates can be determined at any time, and altitude can be determined periodically.

With 24 satellites in the system, there would be at least four space vehicles in view of an observer at any time and at any point on the earth, which would enable an observed vehicle to continuously determine its own coordinates along three axes. With a reduction in the number of satellites to 18, there will be times when there are only three satellites in view of the user, precluding determination of altitude at these instants. U.S. military experts now deem as acceptable the fact that the capabilities of the NavStar system may be reduced; however, this can be overcome in case of dire necessity.

Plans are for NavStar to use a passive ranging system (with high-stability frequency standards on board the satellite and the observed vehicle). The selected principle of navigational measurements enables measurement of navigational quantities with equal success by different classes of observed vehicles regardless of their motion parameters such a velocity, which makes utilization of the system universal. The passive ranging method to a considerable extent predetermines the high speed of computation of coordinates as well, since the signal received from on board the satellite is practically ready for immediate processing. This property of the given method in combination with the chosen version of ballistic construction of the system will enable reception of navigational data in near-real time.

The plan of the system provides for high accuracy characteristics. For example the theoretical mean-square error in determination of location does not exceed 10 m in the horizontal plane and 14 m in the vertical plane, and rates of proper motion -- 0.03 m/s and 0.05 m/s respectively.

U. S. specialists see the principal way to attain the planned accuracy characteristics in precision ephemeris support and development of high-stability on-board frequency standards.

In accordance with the goals of the first stage of the program, six prototype satellites of the NavStar system were placed in orbit in 1978-1980, becoming part of an experimental version of the navigational system together with the NTS-2 experimental satellite launched previously in 1977.

Principal technical characteristics of the satellites: weight (in orbit) approximately 450 kg, maximum size with solar panels extended--5 m, designed service life five years, power of solar batteries at the beginning of operational service about 530 W. The satellite is oriented with respect to three axes by electric flywheel and gas-jet systems.

The navigational equipment of the satellite includes a high-stability rubidium frequency generator (weight 40 kg, volume 2780 cc, power consumption 24.5 W), a transmitter (two working frequencies for transmitting a signal of navigational measurements, working frequency bands 1200-1300 MHz and 1500-1600 MHz, using pseudonoise modulation), an antenna-feeder device (phased array with 12 helical elements), a memory device for storing data on the parameters of the predicted orbit and other information for navigational measurements.

It is planned that the operational models of the satellites will be placed in orbit by groups of a few each by means of the Shuttle spacecraft (in a low-altitude base orbit), and then elevated to the working orbit of 20,000 km altitude by an acceleration stage.

A key component of the satellite equipment is the on-board frequency generators. It has been proposed that each satellite of the operational system be equipped with two generators (one a backup). The first satellites are using rubidium frequency generators that have demonstrated stability in spaceflight equal to a few hundred nanoseconds per day. At this stability level, it is necessary to correct the satellite every few hours. Subsequent models will use more stable cesium frequency generators. According to calculations by U.S. specialists, they can operate

without correction for several days (it is anticipated that their stability can be brought to within a few nanoseconds in 10 days). In the offing is an on-board frequency generator that would be able to operate for several weeks without correction. It is suggested that this can be achieved by using a frequency generator based on a hydrogen maser (the latter has been under development in the United States since 1976).

In addition to the direct influence on accuracy of navigational measurements, the stability level of the on-board frequency generators will also determine the number of ground-based stations intended for their periodic correction. In the case of use of a cesium frequency standard, two stations in the continental United States (one a backup) will be sufficient for correcting the on-board generators of all satellites of the NavStar navigational system, and if the hydrogen standard is used, the system will operate with predetermined accuracy for a long period even when both correcting stations are out of operation.

NavStar uses ground stations of three types: monitor stations, including the main stations at Vandenberg Air Base in California, Alaska, Guam, Hawaii, and spare stations in Maine, Arizona, the Seychelles and the Panama Canal Zone; a main control center at Vandenberg Air Base; and a data transmitting station, also at Vandenberg. The ground stations support operation of the system as a whole.

The monitor stations are unmanned points that receive navigational information from the satellites. Their location has been determined with high precision. Their equipment is analogous to that of the observed vehicles. The navigational information received from the satellites is then transmitted to the main control station, where it undergoes preliminary processing for determining data on the orbital parameters for each satellite operating in the system. The results of the preliminary processing are transmitted each day to the main computing center at Dahlgren Virginia, where they are used as the basis for calculating the orbit of each satellite two weeks in advance. The information on the parameters of the predicted orbit is transmitted daily by the data transmitting station to the satellite for storage in the on-board memory and subsequent relay to the observed vehicles together with other navigational data. On the basis of the information transmitted from the satellites, the observed vehicles determine their own coordinates and rate of motion by means of their computer reception equipment.

Seven classes of potential users of the system are differentiated: A--combat and reconnaisance aircraft of the strategic air command; B--air support aircraft and helicopters, surface vessels of some classes; C--antisubmarine and transport aircraft and helicopters of the rescue service, surface vessels; D--ground and water surface vehicles (wheel and tracked vehicles, mine carriers, surface vessels of some classes); E--isolated operative personnel (pack sets); F--submarines; M--guided missiles.

In view of the diversity of classes and types of potential users of the NavStar system, U. S. specialists are looking for ways to reduce the number of types of computer reception equipment, and to standardize this equipment. It is planned to satisfy the entire aggregate of accuracy, dynamic, size and weight requirements for computer reception equipment of observed vehicles by forming a limited number of equipment groups, each intended for users of one or more classes.

Three groups of computer reception equipment have been formed, conventionally designated X, Y, Z. Portable backpack equipment is set apart. Equipment of group X is intended for users of classes A, B, F; of group Y--for classes D and E (guided missiles were initially assigned to class E, and later set apart in independent class M); of group Z--for class C. the table [not included] gives major design characteristics of computer reception equipment of the various groups on different stages of realization of the program (on the first stage--experimental equipment, on the second--protype equipment, and on the third--operational).

In choosing the design arrangements for the computer reception equipment, U. S. specialists took consideration of requirements for the rate of navigational measurements on board the observed vehicles. These requirements depend on the degree of dynamicity of the vehicle or constraints on the duration of the time interval of observation, and obviously differ for helicopters and tracked vehicles, surface vessels and submarines. With consideration of this fact, equipment of group X uses four- (or more) channel receivers simultaneously operating continuously on signals of four (or more) satellites, equipment of group Y is realized in a one-channel or two-channel version with sequential switching of the channel to signals of other satellites.

At present, all these groups of computer reception equipment for potential users of the NavStar system are in the stage of development or testing, and series production is planned for startup in 1982.

In developing the NavStar system, U.S. military experts are giving considerable attention to questions of viability, which take on even greater importance in connection with the fact that it is planned that the satellites of this system will carry as an extra payload equipment for detecting nuclear explosions and relays for operation in the airforce Afsatcom communication system with strategic capabilities. In their opinion, the very concept of the system design presupposes its invunerability in large measure. Being considered in particular as additional measures is the possibility of maneuvering the satellites in orbit. Also being considered is the problem of placing additional satellites with more powerful transmitters in a stationary orbit in the zone of visibility of the European territory to ensure reception of navigational information under the high interference conditions of Central Europe.

In 1978, NATO nations were granted permission by the United States to take part in developing and using the NavStar system. Emphasis was placed on the necessity of standardizing computer reception equipment on observed vehicles within the NATO framework. From this we see that NavStar is becoming a unified navigational system for NATO countries.

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LAUNCH TABLE

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
17 Jul 81	Cosmos-1283	278 km	184 km	88.9 min	82.3
		(Earth resources satellite; data will be processed at State Scientific-Research and Production Center "Priroda")			
29 Jul 81	Cosmos-1284	270 km	195 km	88.8 min	82.3
31 Jul 81	Raduga	36,690 km	—	24 hrs 37 min	0.4
		(Near-stationary circular orbit; communications satellite for relay of telephone, telegraph and TV signals in centimeter wave band; international registration index: "Statsionar-2")			
4 Aug 81	Cosmos-1285	40,165 km	630 km	12 hrs 06 min	62.8
4 Aug 81	Cosmos-1286	453 km	433 km	93.24 min	65
6 Aug 81	Cosmos-1287--Cosmos-1294	1,058 km	1,446 km	115.2 min	74
		(Eight satellites launched by single booster)			
7 Aug 81	Intercosmos-Bulgaria 1300	906 km	825 km	101.9 min	81.2
		(To study ionosphere, magnetosphere and upper layers of atmosphere; carries scientific apparatus developed and manufactured by Bulgarian scientists)			
12 Aug 81	Cosmos-1295	1,026 km	966 km	104.8 min	82.9

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
13 Aug 81	Cosmos-1296	377 km	181 km	89.8 min	67.2
18 Aug 81	Cosmos-1297	389 km	209 km	90.2 min	72.9
21 Aug 81	Cosmos-1298	351 km	179 km	89.5 min	64.9
25 Aug 81	Cosmos-1299	281 km	250 km	89.7 min	65
25 Aug 81	Cosmos-1300	675 km	648 km	97.7 min	82.5
27 Aug 81	Cosmos-1301	300 km	224 km	89.4 min	82.3
28 Aug 81	Cosmos-1302	824 km	783 km	100.8 min	74
28 Aug 81	Vertikal'-9	(Geophysical rocket launched to altitude of 500 km to study short-wave solar radiation; carried Soviet, Polish and Czech equipment)			
4 Sep 81	Cosmos-1303	398 km	216 km	90.4 min	70.4
4 Sep 81	Cosmos-1304	984 km	917 km	104 min	83
11 Sep 81	Cosmos-1305	13,870 km	648 km	4 hrs 24 min	63
15 Sep 81	Cosmos-1306	494 km	156 km	90.9 min	65
15 Sep 81	Cosmos-1307	419 km	209 km	90.4 min	72.9

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